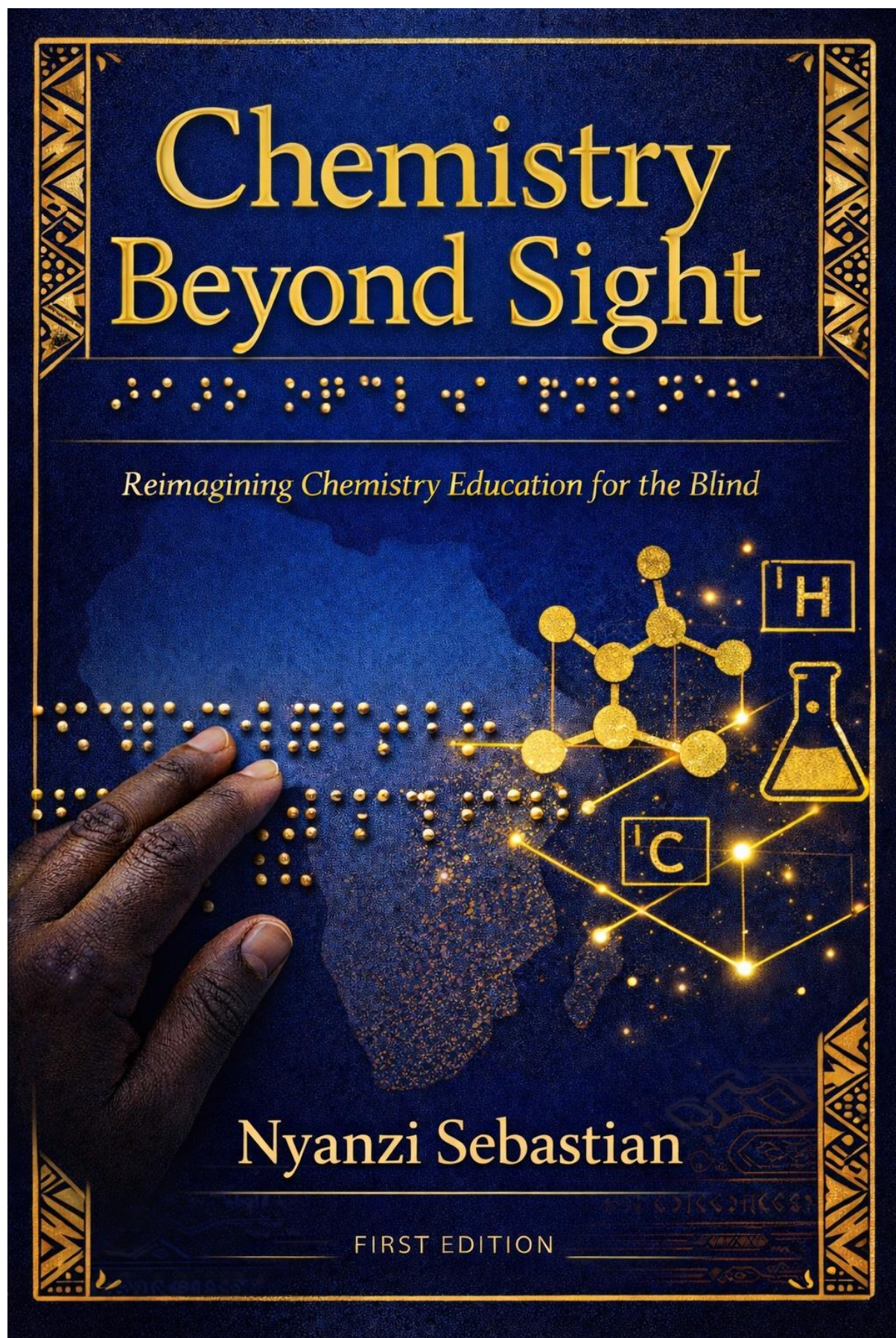




“In every atom lies a universe; in every reaction, a story. Open this book, and let your hands see what eyes could never imagine.”

Sebastian Nyanzi
Author
Chemistry Beyond Sight
A Book for the Blind
and Visually Impaired

Sebastian Nyanzi

Author
Chemistry Beyond Sight

For centuries, chemistry has been seen as a science of sight molecules, reactions, and equations presented visually, often leaving blind learners on the sidelines.

Today, we begin a new chapter in education: a book that unites the visually impaired and sighted in the joy of discovery.

This book is a bridge, where touch meets logic, and adapted symbols and Braille-compatible systems make molecules tangible and equations accessible.

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We invite students of all abilities to explore, experiment, and understand chemistry fully, without limitation.

Chemistry is a science that explores the properties and interactions of matter. It is a field that is constantly evolving, and it is one that is essential to our understanding of the world around us. Chemistry is a science that is both fascinating and challenging, and it is one that is essential to our understanding of the world around us.

This book is here to ignite curiosity, nurture creativity, and empower learners to change the world.

Chemistry is a science that explores the properties and interactions of matter. It is a field that is constantly evolving, and it is one that is essential to our understanding of the world around us. Chemistry is a science that is both fascinating and challenging, and it is one that is essential to our understanding of the world around us.

Because chemistry is not just about what we see it's about what we can imagine, understand, and create.

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With this book, no learner is left behind together, we build a generation of scientists ready to transform society.

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ACKNOWLEDGEMENT

I wish to express my profound gratitude to all individuals and institutions whose support, guidance, and belief made the completion of this book possible.

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First and above all, I extend my deepest appreciation to my father, Mr. Kiyanzi John, whose sacrifices, resilience, and unwavering commitment to education shaped not only this work but also the person behind it.

[illegible]

In moments of uncertainty and limitation, his guidance, discipline, and encouragement remained a constant source of

strength.

His belief in purpose, hard work, and integrity continues to inspire my pursuit of knowledge and service to society.

This book stands as a reflection of the values he instilled and the vision he continues to uphold.

I am sincerely grateful to the institutions that nurtured my academic and personal growth, particularly St. Balikuddembe Secondary School Kisoga, St. Mary's College Kisubi, and St. Mary's College Lugazi.

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I also extend my sincere gratitude to Ms. Kagoya Lydia, the Head Teacher of St. Balikuddembe Secondary School Kisoga, for her leadership, encouragement, and commitment to fostering a culture of learning and innovation.

[illegible]

I also express my heartfelt appreciation to Makerere University, Department of Chemistry, for the academic exposure and mentorship that greatly influenced this work.

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I acknowledge fellow students, teachers, mentors, and members of the scientific community whose discussions, feedback, and encouragement contributed meaningfully to the ideas presented in this book.

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Above all, this work is inspired by the belief that science should be accessible to all.

[illegible]

Braille representation of the first paragraph of text.

I dedicate this book to learners everywhere—especially students with visual impairments—whose determination continues to challenge limitations and redefine what is possible through inclusive education.

Braille representation of the second paragraph of text.

Braille representation of a short line of text.

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INTRODUCTION TO CHEMISTRY

Chemistry is a science that studies the properties, composition, and behavior of matter. It is a fundamental part of our world and plays a crucial role in many aspects of our lives, from the food we eat to the technology we use.

Reasons Why Blind Students Should Study Chemistry

There are several reasons why blind students should study chemistry. First, it provides a unique perspective on the world around us. Second, it helps develop critical thinking and problem-solving skills. Third, it opens up career opportunities in various fields.

Equal Opportunity in Science Education

Blind students have the right to access the same educational opportunities as sighted students. This includes the right to learn chemistry and other sciences. It is essential to provide the necessary accommodations and resources to ensure equal access.

Blind students have the right to access the same educational opportunities as sighted students.

Studying chemistry allows them to develop critical thinking, problem-solving, and practical skills. These skills are valuable in many careers and are essential for a well-rounded education. Chemistry also provides a deeper understanding of the natural world and the processes that govern it.

Studying chemistry allows them to develop critical thinking, problem-solving, and practical skills.

Chemistry is a dynamic and exciting field that offers many opportunities for discovery and innovation. By studying chemistry, blind students can gain a deeper understanding of the world and develop the skills needed to succeed in a variety of careers. It is a field that is constantly evolving and offers a wealth of knowledge and discovery.

Career and Professional Opportunities

Chemistry knowledge opens doors to careers in medicine, research, environmental science, engineering, and industrial sectors.

Blind students should not be excluded from these opportunities.

Chemistry knowledge opens doors to careers in medicine, research, environmental science, engineering, and industrial sectors. Blind students should not be excluded from these opportunities.

Hands-On Learning Through Adapted Tools

With tactile models, Braille texts, audible simulations, and adapted lab equipment, blind students can actively participate in experiments and learn concepts just like sighted students.

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Chemistry knowledge opens doors to careers in medicine, research, environmental science, engineering, and industrial sectors. Blind students should not be excluded from these opportunities.

Braille representation of the first paragraph.

Inclusivity and Social Integration

Braille representation of the second paragraph.

Inclusive chemistry education encourages collaboration between blind and sighted students, promoting teamwork, empathy, and mutual respect.

Braille representation of the third paragraph.

Dual-Use Learning Materials

Braille representation of the fourth paragraph.

The chemistry book can be designed to serve both blind and sighted learners, making it a versatile educational tool.

Braille representation of the fifth paragraph.

The Braille representation of the sentence "The cat sat on the mat." consists of two rows of dots. The first row contains the words "The", "cat", "sat", "on", "the", and "mat.", each followed by a space character represented by two dots in the bottom-left position.

Addressing the Innovation Gap

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Very many blind students have historically been left out of the chemistry world.

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There was a clear need for an accessible resource that enables blind students to learn chemistry effectively.

[illegible]

This book comes as an answer to all of this.




Empowering Independence and Confidence

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840.

Studying chemistry equips blind students with knowledge and skills to conduct research, engage in STEM activities, and pursue independent learning.

Chemistry is a science that studies the properties, composition, and behavior of matter. It is a field that is constantly evolving and expanding, and it is one of the most important and exciting areas of research in the world. Chemistry is a science that is essential to our understanding of the world around us, and it is a field that is constantly evolving and expanding. Chemistry is a science that is essential to our understanding of the world around us, and it is a field that is constantly evolving and expanding.

Fosters self-confidence and empowerment.

Chemistry is a science that is essential to our understanding of the world around us, and it is a field that is constantly evolving and expanding. Chemistry is a science that is essential to our understanding of the world around us, and it is a field that is constantly evolving and expanding.

SYMBOLS, VALENCY, CHEMICAL FORMULA and EQUATIONS

Chemical symbols are abbreviations for the names of elements. They are written in capital letters. Some symbols have two letters, the first in capital and the second in small letters.

Symbol of elements

Chemical symbols are abbreviations for the names of elements.

The symbol of an element is one or two letters which mean one atom of the element.

For example, the symbol for Hydrogen is H, for Carbon is C, for Oxygen is O, for Nitrogen is N, for Sodium is Na, for Potassium is K, for Calcium is Ca, for Magnesium is Mg, for Iron is Fe, for Copper is Cu, for Zinc is Zn, for Silver is Ag, for Gold is Au, for Mercury is Hg, for Lead is Pb, for Tin is Sn, for Antimony is Sb, for Bismuth is Bi, for Arsenic is As, for Selenium is Se, for Tellurium is Te, for Iodine is I, for Bromine is Br, for Chlorine is Cl, for Fluorine is F, for Neon is Ne, for Argon is Ar, for Krypton is Kr, for Xenon is Xe, for Radon is Rn, for Francium is Fr, for Radium is Ra, for Actinium is Ac, for Thorium is Th, for Protactinium is Pa, for Uranium is U, for Neptunium is Np, for Plutonium is Pu, for Americium is Am, for Curium is Cm, for Berkelium is Bk, for Californium is Cf, for Einsteinium is Es, for Fermium is Fm, for Mendelevium is Md, for Nobelium is No, for Lawrencium is Lr, for Rutherfordium is Rf, for Dubnium is Db, for Seaborgium is Sg, for Bohrium is Bh, for Hassium is Hs, for Meitnerium is Mt, for Darmstadtium is Dst, for Roentgenium is Rg, for Copernicium is Cn, for Nihonium is Nh, for Flerovium is Fl, for Tennessine is Ts, for Oganesson is Og.

It is usually the first letter of the English or Latin name of the elements.

For example, the symbol for Hydrogen is H, for Carbon is C, for Oxygen is O, for Nitrogen is N, for Sodium is Na, for Potassium is K, for Calcium is Ca, for Magnesium is Mg, for Iron is Fe, for Copper is Cu, for Zinc is Zn, for Silver is Ag, for Gold is Au, for Mercury is Hg, for Lead is Pb, for Tin is Sn, for Antimony is Sb, for Bismuth is Bi, for Arsenic is As, for Selenium is Se, for Tellurium is Te, for Iodine is I, for Bromine is Br, for Chlorine is Cl, for Fluorine is F, for Neon is Ne, for Argon is Ar, for Krypton is Kr, for Xenon is Xe, for Radon is Rn, for Francium is Fr, for Radium is Ra, for Actinium is Ac, for Thorium is Th, for Protactinium is Pa, for Uranium is U, for Neptunium is Np, for Plutonium is Pu, for Americium is Am, for Curium is Cm, for Berkelium is Bk, for Californium is Cf, for Einsteinium is Es, for Fermium is Fm, for Mendelevium is Md, for Nobelium is No, for Lawrencium is Lr, for Rutherfordium is Rf, for Dubnium is Db, for Seaborgium is Sg, for Bohrium is Bh, for Hassium is Hs, for Meitnerium is Mt, for Darmstadtium is Dst, for Roentgenium is Rg, for Copernicium is Cn, for Nihonium is Nh, for Flerovium is Fl, for Tennessine is Ts, for Oganesson is Og.

However, some elements have two letters.

For example, the symbol for Hydrogen is H, for Carbon is C, for Oxygen is O, for Nitrogen is N, for Sodium is Na, for Potassium is K, for Calcium is Ca, for Magnesium is Mg, for Iron is Fe, for Copper is Cu, for Zinc is Zn, for Silver is Ag, for Gold is Au, for Mercury is Hg, for Lead is Pb, for Tin is Sn, for Antimony is Sb, for Bismuth is Bi, for Arsenic is As, for Selenium is Se, for Tellurium is Te, for Iodine is I, for Bromine is Br, for Chlorine is Cl, for Fluorine is F, for Neon is Ne, for Argon is Ar, for Krypton is Kr, for Xenon is Xe, for Radon is Rn, for Francium is Fr, for Radium is Ra, for Actinium is Ac, for Thorium is Th, for Protactinium is Pa, for Uranium is U, for Neptunium is Np, for Plutonium is Pu, for Americium is Am, for Curium is Cm, for Berkelium is Bk, for Californium is Cf, for Einsteinium is Es, for Fermium is Fm, for Mendelevium is Md, for Nobelium is No, for Lawrencium is Lr, for Rutherfordium is Rf, for Dubnium is Db, for Seaborgium is Sg, for Bohrium is Bh, for Hassium is Hs, for Meitnerium is Mt, for Darmstadtium is Dst, for Roentgenium is Rg, for Copernicium is Cn, for Nihonium is Nh, for Flerovium is Fl, for Tennessine is Ts, for Oganesson is Og.

Writing the symbol of an element which has two letters, the first letter is written as capital letter and second one as a small letter.

For example, the symbol for Hydrogen is H, for Carbon is C, for Oxygen is O, for Nitrogen is N, for Sodium is Na, for Potassium is K, for Calcium is Ca, for Magnesium is Mg, for Iron is Fe, for Copper is Cu, for Zinc is Zn, for Silver is Ag, for Gold is Au, for Mercury is Hg, for Lead is Pb, for Tin is Sn, for Antimony is Sb, for Bismuth is Bi, for Arsenic is As, for Selenium is Se, for Tellurium is Te, for Iodine is I, for Bromine is Br, for Chlorine is Cl, for Fluorine is F, for Neon is Ne, for Argon is Ar, for Krypton is Kr, for Xenon is Xe, for Radon is Rn, for Francium is Fr, for Radium is Ra, for Actinium is Ac, for Thorium is Th, for Protactinium is Pa, for Uranium is U, for Neptunium is Np, for Plutonium is Pu, for Americium is Am, for Curium is Cm, for Berkelium is Bk, for Californium is Cf, for Einsteinium is Es, for Fermium is Fm, for Mendelevium is Md, for Nobelium is No, for Lawrencium is Lr, for Rutherfordium is Rf, for Dubnium is Db, for Seaborgium is Sg, for Bohrium is Bh, for Hassium is Hs, for Meitnerium is Mt, for Darmstadtium is Dst, for Roentgenium is Rg, for Copernicium is Cn, for Nihonium is Nh, for Flerovium is Fl, for Tennessine is Ts, for Oganesson is Og.

The diagram shows the layout of the 26 letters of the alphabet in a 2x13 grid. The top row contains letters A through M, and the bottom row contains letters N through Z. Each letter is represented by a unique pattern of black dots on a white background.

| Element | Latin Name |
|-----------|-------------|
| Potassium | Kalium |
| Sodium | Natrium |
| Iron | Ferrum |
| Lead | Plumbum |
| Copper | Cuprum |
| Mercury | Hydrargyrum |
| Silver | Argentum |

The figure consists of a 4x8 grid of 32 small diagrams. Each diagram shows a unique spatial arrangement of 10 black dots within a square frame. The dots are positioned at various coordinates, creating a variety of patterns for a matching task. The patterns range from simple horizontal or vertical lines to more complex, irregular clusters.

The top 20 elements of the periodic table



1. Hydrogen (H)



2. Helium (He)



3. Lithium (Li)



4. Beryllium (Be)



5. Boron (B)



6. Carbon (C)



7. Nitrogen (N)



8. Oxygen (O)



9. Fluorine (F)



10. Neon (Ne)



11. Sodium (Na)



12. Magnesium (Mg)



13. Aluminium (Al)



14. Silicon (Si)



15. Phosphorus (P)



16. Sulphur (S)



17. Chlorine (Cl)



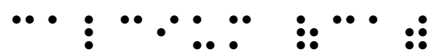
18. Argon (Ar)



19. Potassium (K)



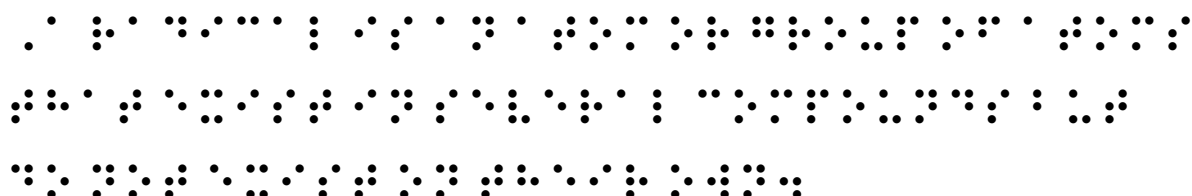
20. Calcium (Ca)



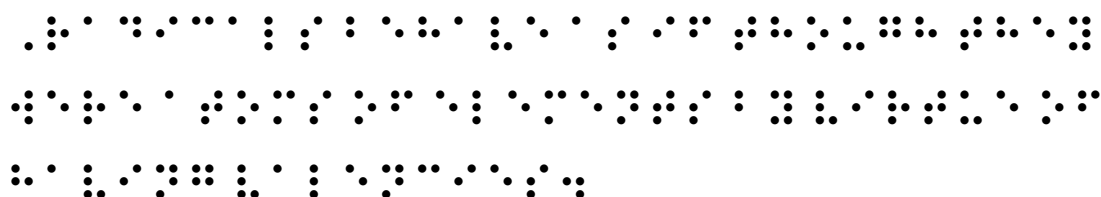
Radicals



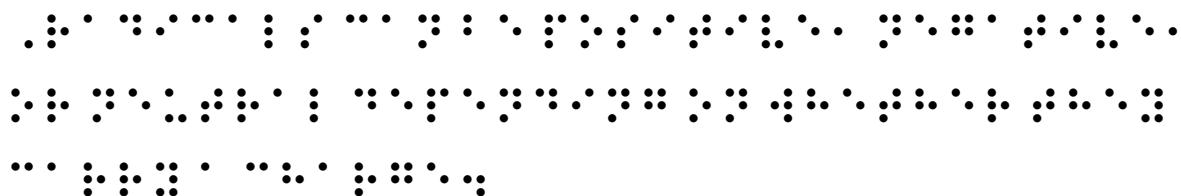
A radical is an atom or group of atoms that exist in several compounds but do not exist on their own.



Radicals behave as if though they were atoms of elements by virtue of having valencies.

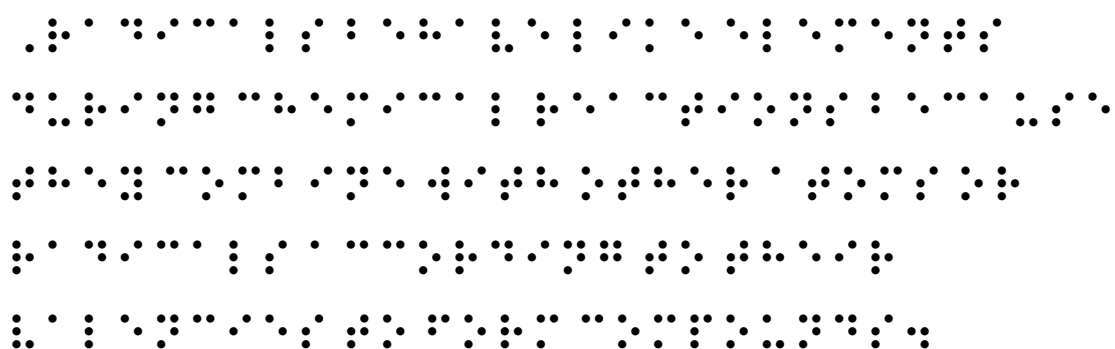


Radicals can be positive, negative, or neutral depending on whether they carry a charge.

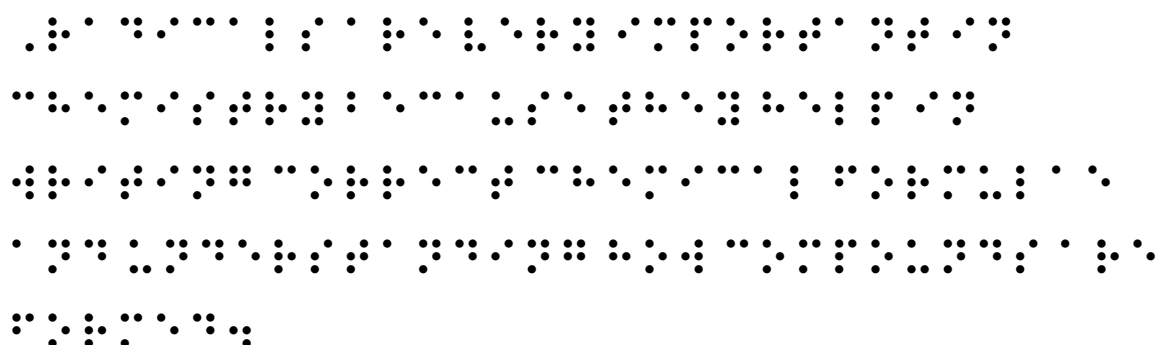


Positive radicals (cations):





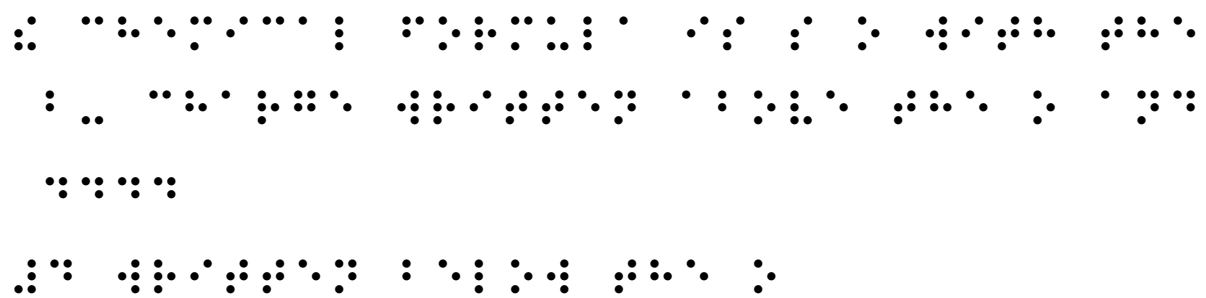
Radicals are very important in chemistry because they help in writing correct chemical formulae and understanding how compounds are formed.



How to write braille radical chemical formulae.



The chemical formula is S O with the 2 minus (2-) charge written above the O and 4 written below the O.



Hydroxide



Symbol



—

O H



Nitrate



Symbol



—

N O

3

..

: :

..

Carbonate

.. : : : : : :

Symbol

.. : : : : :

2—

C O

3

: ..

.. :

..

Sulfate

: : : : : :

Symbol

.. : : : : :

2-

S O

4

: :

: :

: :

Ammonium

· : : : : : : :

Symbol

: : : : : :

+

N H

4

:

: :

: :

Phosphate

: : : : : : :

Symbol

: : : : : :

3-

P O

4

..:

: :

..:

Acetate

· · · · · : : :

Symbol

..: : : : :

-

C H O

2 3 2

..

· · : :

: · :

Chlorate

· · : : : : : :

Symbol

..: : : : :

—

Cl O

3

∴

∴ ∴ ∴

∴

Bromate

∴ ∴ ∴ ∴ ∴ ∴

Symbol

∴ ∴ ∴ ∴ ∴ ∴

—

Br O

3

∴

∴ ∴ ∴

∴

Iodate

∴ ∴ ∴ ∴ ∴ ∴

Symbol

∴ ∴ ∴ ∴ ∴ ∴

—

I O

3

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Cyanide

· · · · · · · · · ·

Symbol

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—

C N

..

· · · ·

Hydrogen carbonate (Bicarbonate)

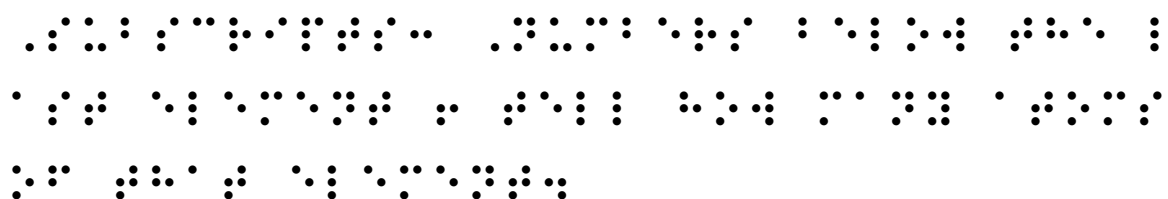
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Symbol

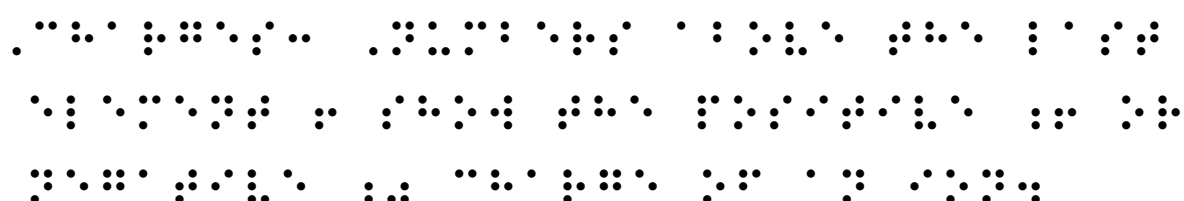
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Subscripts: Numbers below the last element → tell how many atoms of that element.



Charges: Numbers above the last element → show the positive (+) or negative (-) charge of an ion.



Example: Sulfate $\rightarrow \text{SO}_4^{2-}$

2-

SO

4

• •

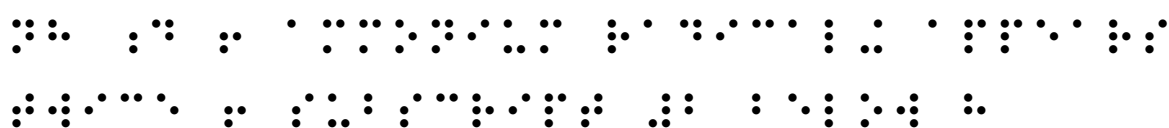
3. Writing Simple Compounds



Steps:



NH_4 = ammonium radical, appears twice $\rightarrow$ subscript 2 below H



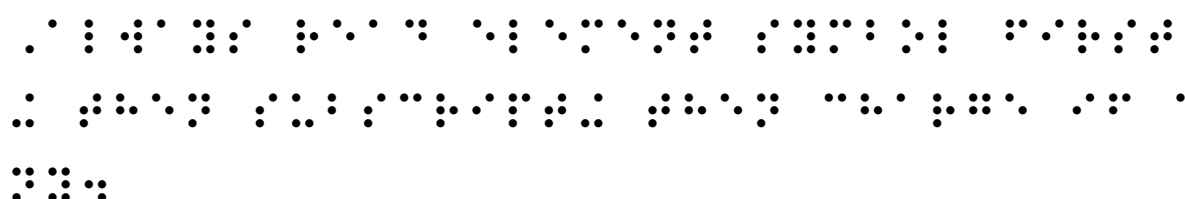
SO_4 = sulfate radical



5. Reading Formulae Aloud

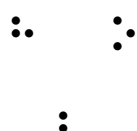


Always read element symbol first, then subscript, then charge if any.



Examples:

H₂O → Hydrogen 2, Oxygen 1


$$\text{SO}_4^{2-} \rightarrow \text{"Sulfur 1, Oxygen 4, charge 2 minus"}$$



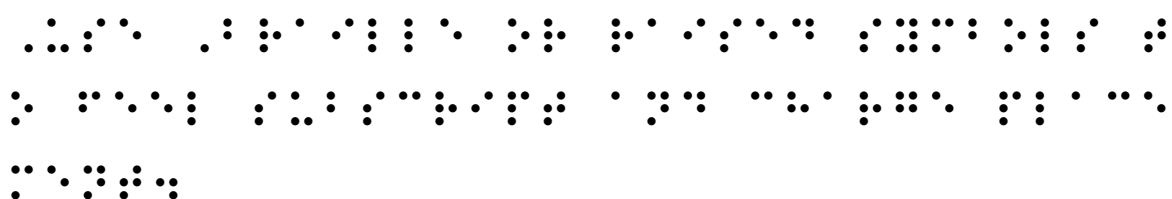

$\text{NH}_4^+ \rightarrow$ “Nitrogen 1, Hydrogen 4, charge plus”



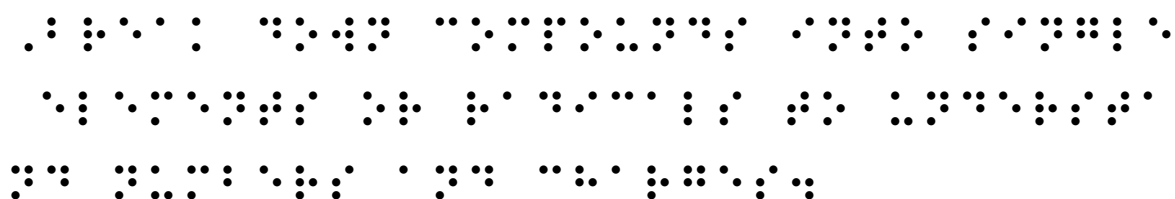
6. Tips for Blind Learners



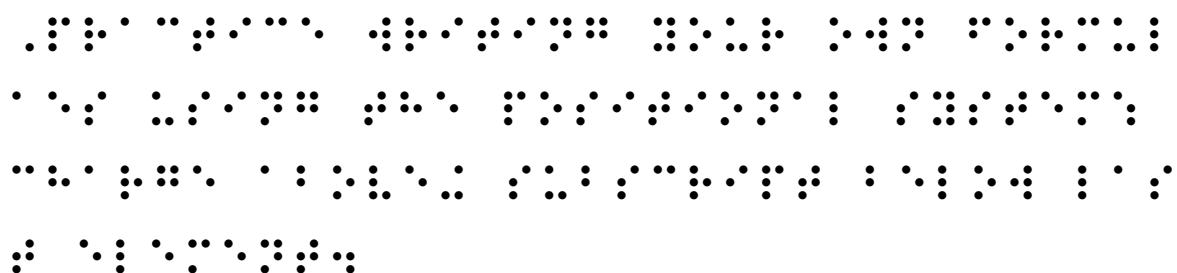
Use Braille or raised symbols to feel subscript and charge placement.



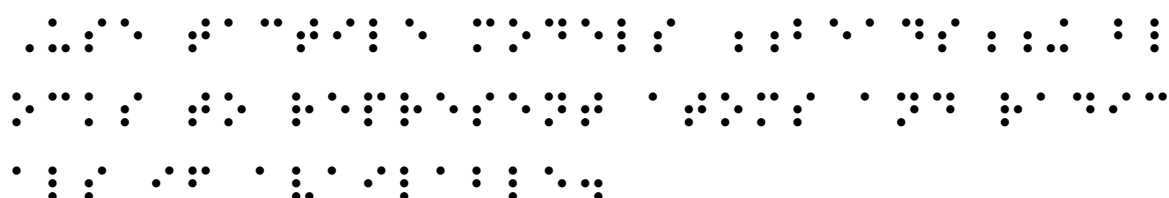
Break down compounds into single elements or radicals to understand numbers and charges.



Practice writing your own formulas using the positional system:
charge above, subscript below last element.



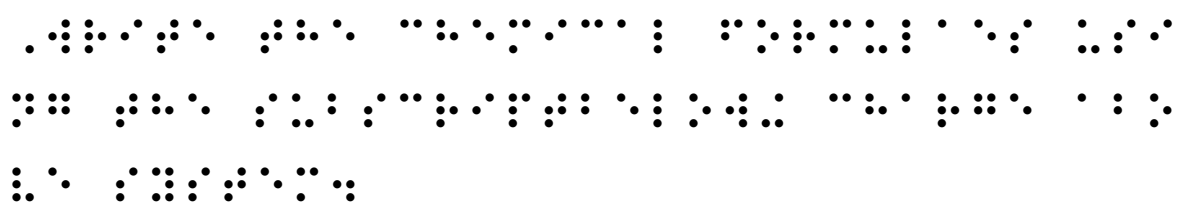
Use tactile models (beads, blocks) to represent atoms and radicals if available.



7. Practice Examples



Write the chemical formulae using the subscript-below, charge-above system:



Example 1: Potassium nitrate $\rightarrow \text{KNO}_3$

K N O

3

[illegible]

- Write the symbols for the elements and radicals.

[illegible]

- Write the valency above and to the right of the symbols and radicals.

• 1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840.

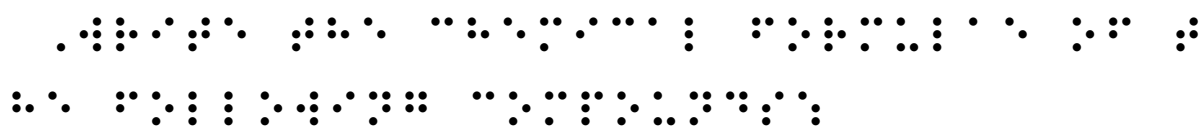
- Reverse the valencies and write the numbers (other than 1) below and to the right

[illegible]

Examples

• • • • •

Write the chemical formulae of the following compounds.



(a) Sodium chloride



(b) Sodium sulphate



(c) Copper (II) chloride



(d) Carbondioxide



(e) Water



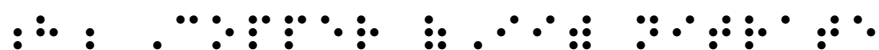
(f) Copper (II) carbonate



(g) Ammonium sulphate



(h) Copper (II) nitrate



(i) Iron (II) sulphate



(j) Iron (III) sulphate



(k) Potassium sulphate



(l) Potassium phoaphate



(m) Sulphuric acid



(n) Nitric acid



(o) Hydrogen chloride



(p) Lead (II) chloride



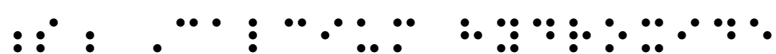
(q) Magnesium hydroxide



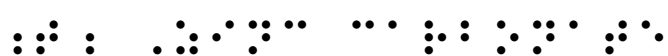
(r) Sodium hydroxide



(s) Calcium hydroxide



(t) Zinc carbonate



Chemical Equations

Chemical equation

A chemical equation represents a chemical change by means of symbols and formulae, i.e., a statement that represents a chemical reaction.

Chemical equation

Included in a chemical equation are:

Chemical equation

- Reactants

Chemical equation

- Products

Chemical equation

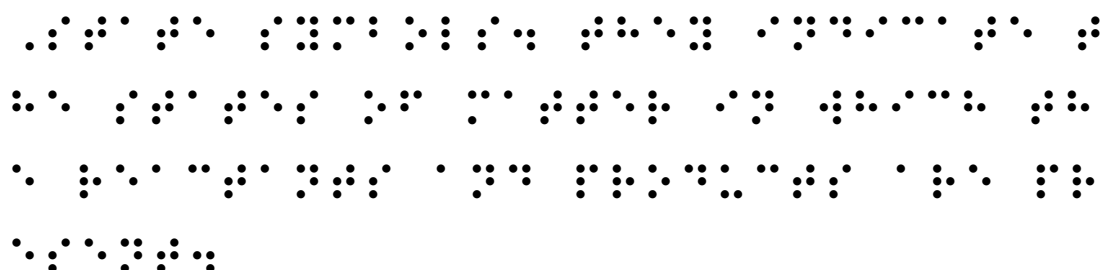
- Proportion of reactants and products

Chemical equation

- Direction of reaction



- State symbols. They indicate the states of matter in which the reactants and products are present, i.e.,



- Solid (s)



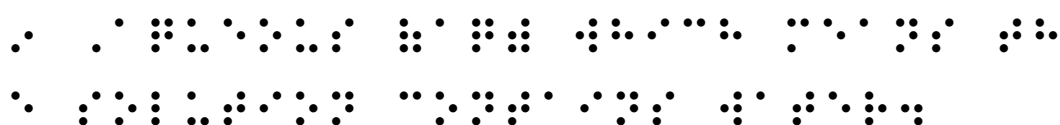
- Liquid (l)



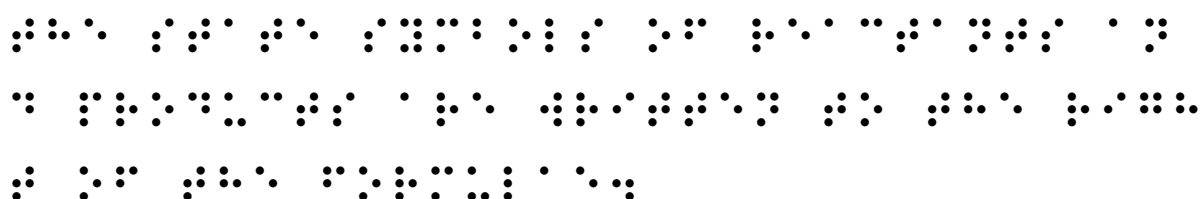
- Gas (g)



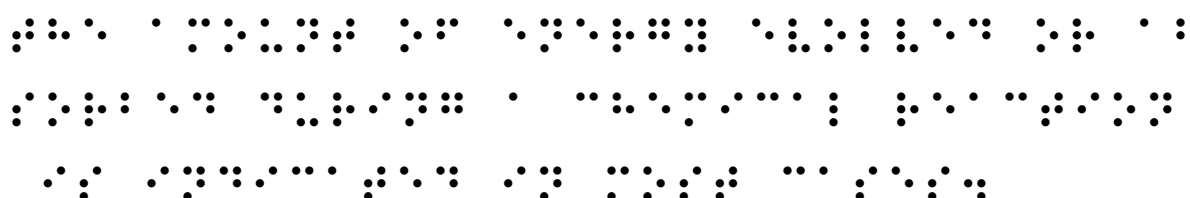
- Aqueous (aq), which means the solution contains water.



The state symbols of reactants and products are written to the right of the formulae.



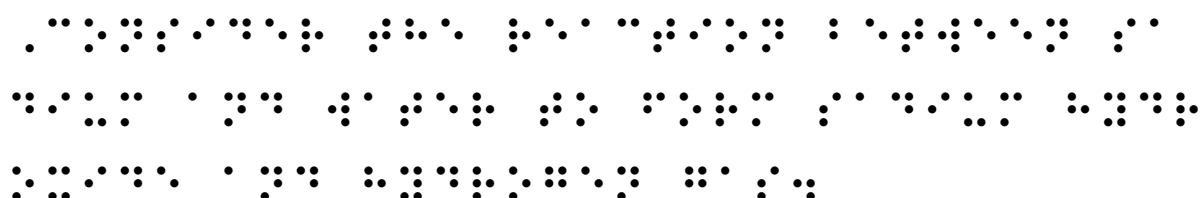
The amount of energy evolved or absorbed during a chemical reaction is indicated in most cases.



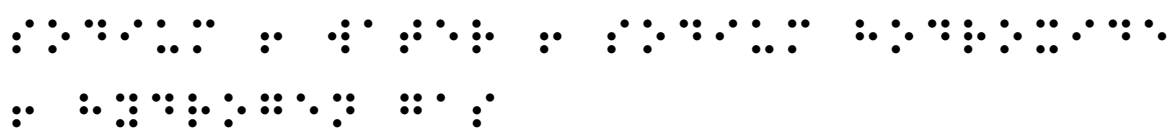
Example Reaction:

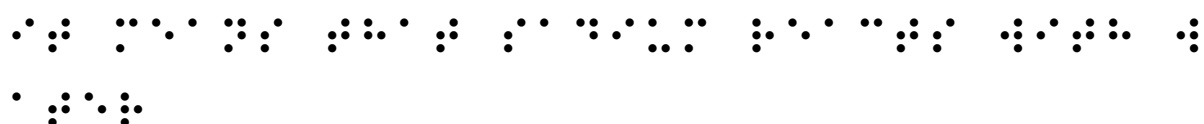


Consider the reaction between sodium and water to form sodium hydroxide and hydrogen gas.

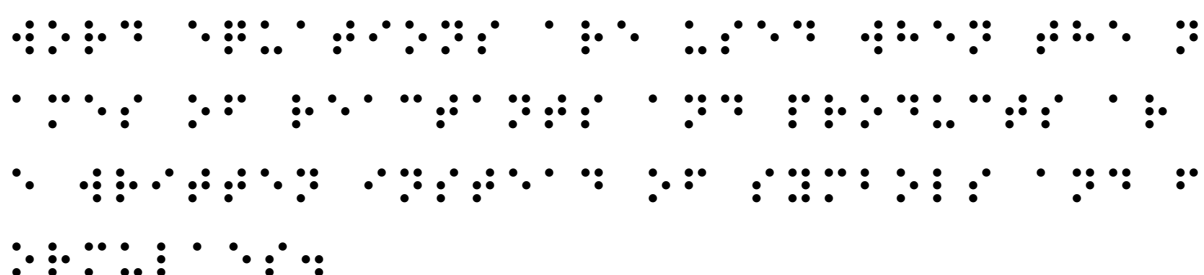


Sodium + Water → Sodium hydroxide + Hydrogen gas



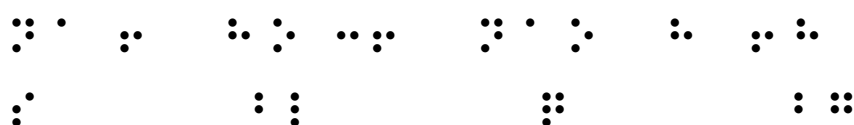


Word Equations are used when the names of reactants and products are written instead of symbols and formulae.

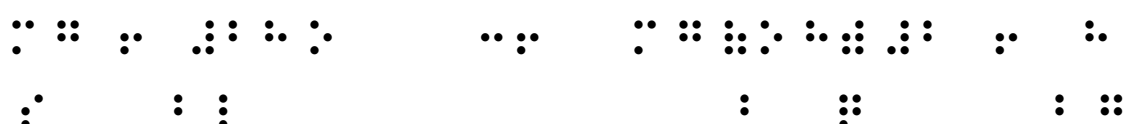


Example:

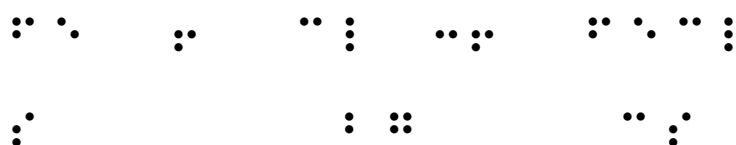
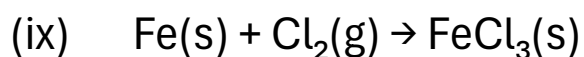
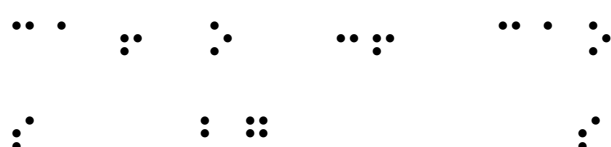
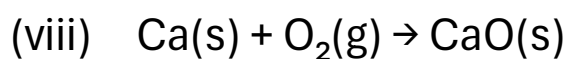
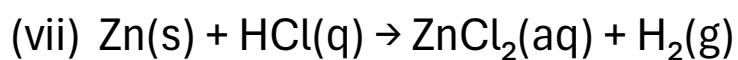
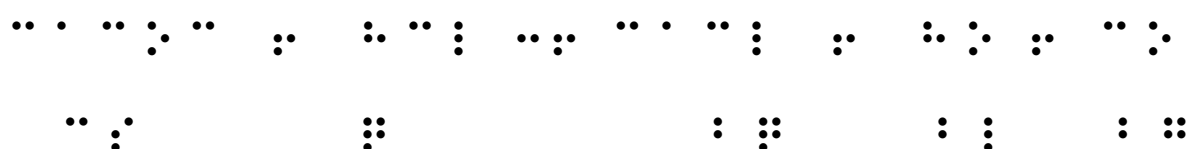
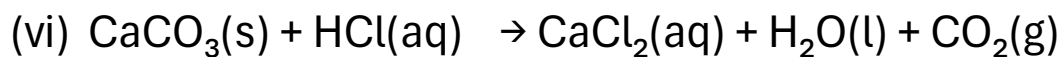
1) Sodium and water:



2) Magnesium and water:



(vi) Calcium carbonate + Hydrochloric acid → Calcium chloride + Water + Carbon dioxide



Balancing chemical equations

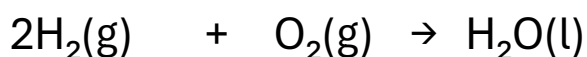
Chemical equations are balanced by making the total number of each kind of atom on the left-hand side of the equation equal to the number on the right-hand side.

This is the making of the total number of each kind of atom on the left-hand side of the equation equal to the number on the right-hand side.

Chemical equations are balanced by making the total number of each kind of atom on the left-hand side of the equation equal to the number on the right-hand side.

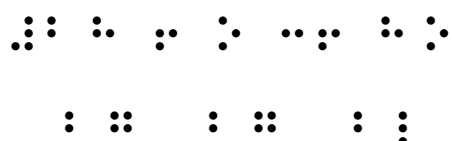
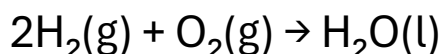
Example of balancing a chemical equation:

Chemical equations are balanced by making the total number of each kind of atom on the left-hand side of the equation equal to the number on the right-hand side.

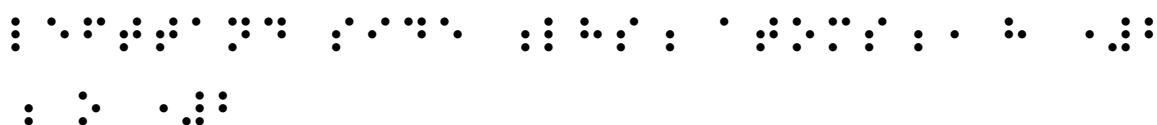


Chemical equations are balanced by making the total number of each kind of atom on the left-hand side of the equation equal to the number on the right-hand side.

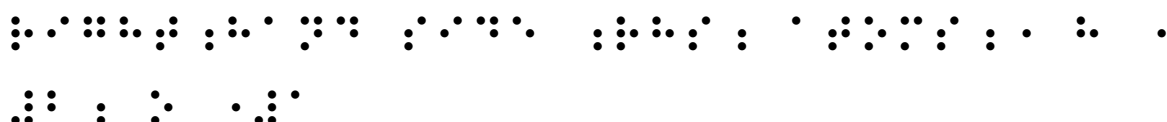
Equation



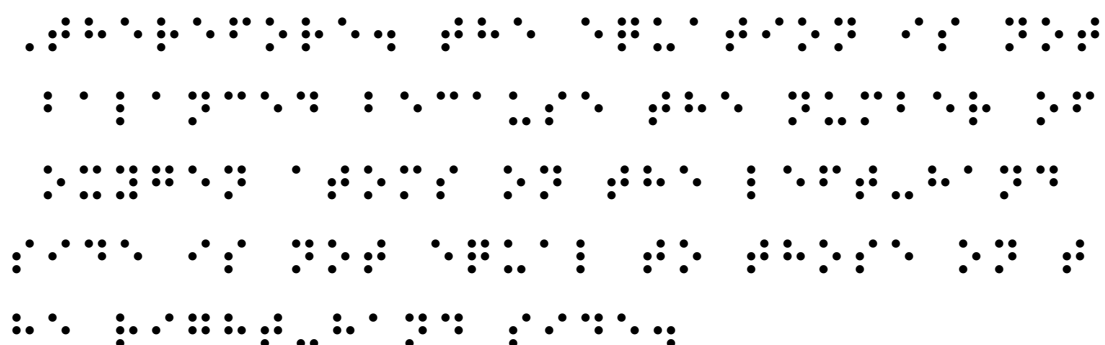
Left-hand side (LHS) atoms: H = 2, O = 2



Right-hand side (RHS) atoms: H = 2, O = 1



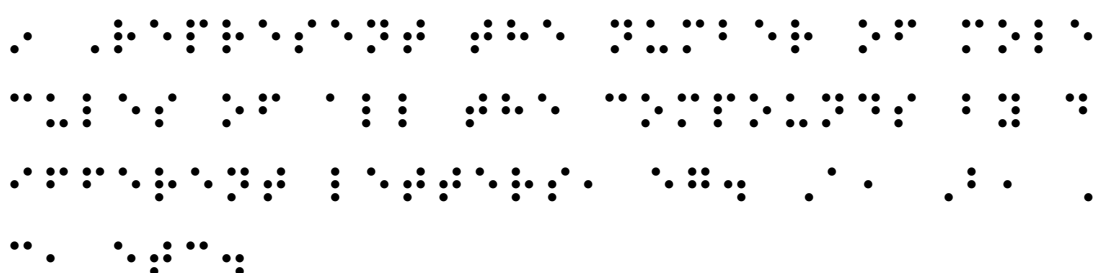
Therefore, the equation is not balanced because the number of oxygen atoms on the left-hand side is not equal to those on the right-hand side.



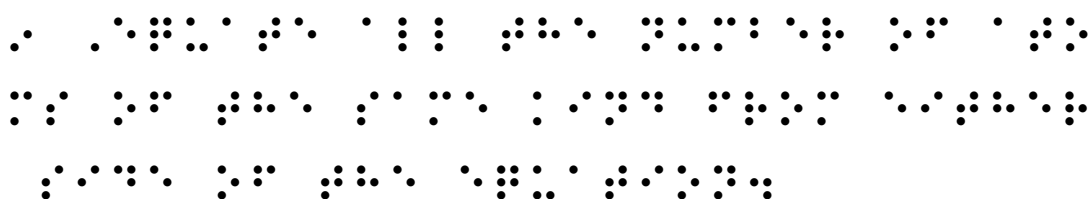
Rules for balancing molecular chemical equations:



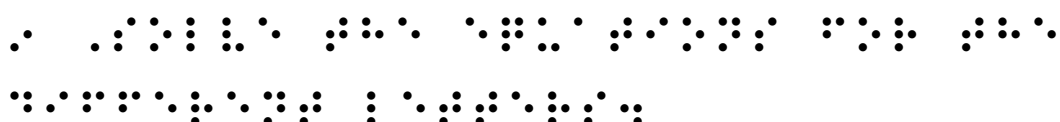
- Represent the number of molecules of all the compounds by different letters, e.g., A, B, C, etc.



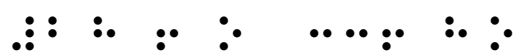
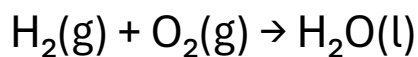
- Equate all the number of atoms of the same kind from either side of the equation.



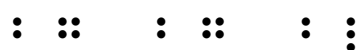
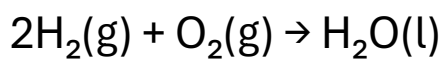
- Solve the equations for the different letter



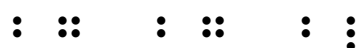
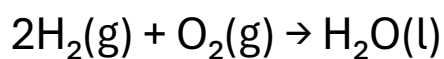
Unbalanced equation



After introducing coefficient 2



Balanced equation (FINAL)



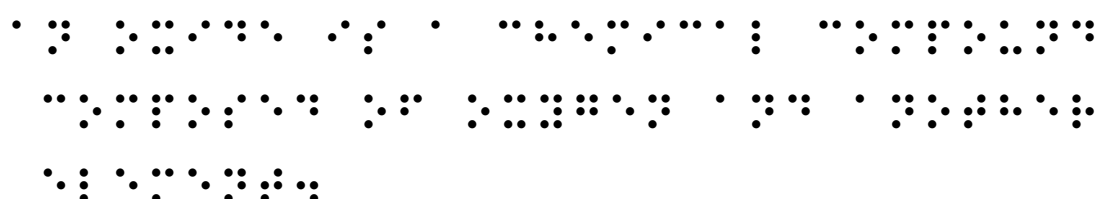
Oxides



Definition:



An oxide is a chemical compound composed of **oxygen** and **another element**.



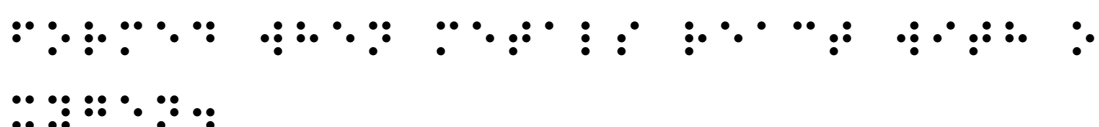
Types of Oxides:



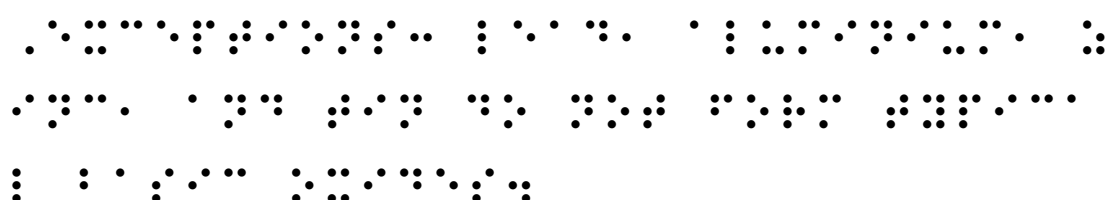
1. Basic Oxides:



- Formed when **metals react with oxygen**.



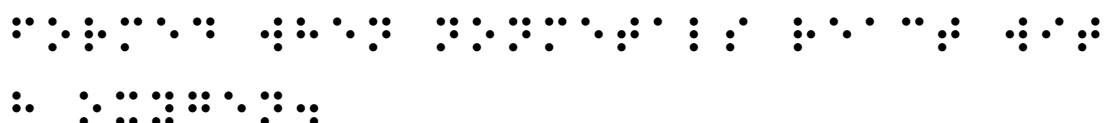
- Exceptions:** lead, aluminium, zinc, and tin do not form typical basic oxides.



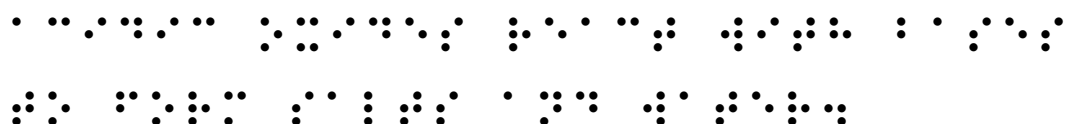
2. Acidic Oxides:



- Formed when **non-metals** react with **oxygen**.



- Acidic oxides react with **bases** to form salts and water.



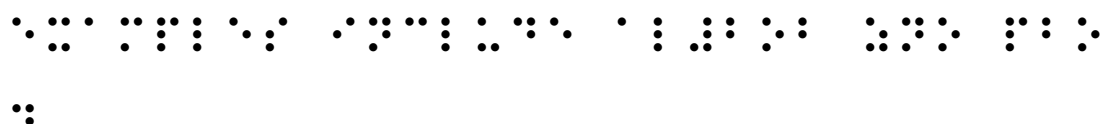
3. Amphoteric Oxides:



- Oxides that can react with **both acids and bases**.



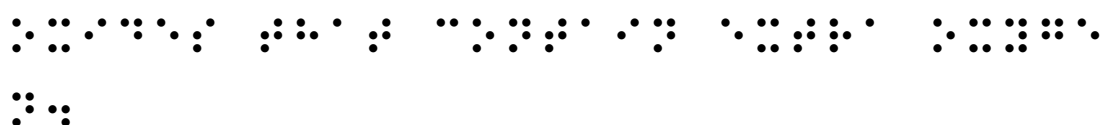
- Examples include **Al₂O₃, ZnO, PbO**.



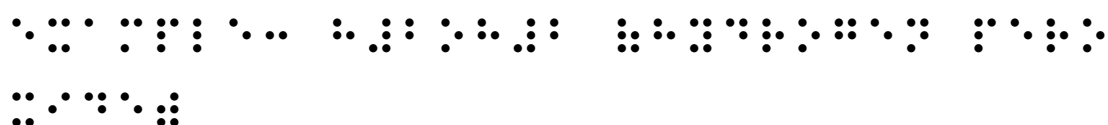
4. Peroxides:



- Oxides that contain **extra oxygen**.



- Example: **H₂O₂ (hydrogen peroxide)**.



Importance of Oxides:

Oxides are essential in everyday life: used in cement, fertilizers, glass, and metal extraction.

- Oxides are essential in **everyday life**: used in **cement, fertilizers, glass, and metal extraction**.

They help predict **chemical reactions**:

- They help predict **chemical reactions**:

- Acids** react with **basic oxides**.

- Bases** react with **acidic oxides**.

Chemical reactions involving oxides:

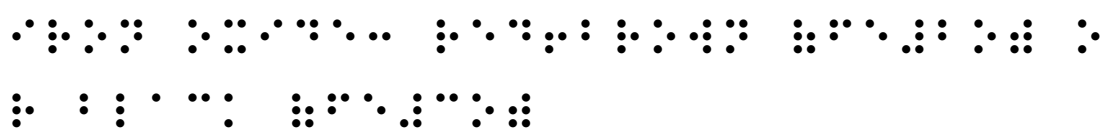
Colour of Common Oxides:

Chemical reactions involving oxides:

- Copper oxide**: black (CuO) or red (Cu_2O)

Chemical reactions involving oxides:

- **Iron oxide:** red-brown (Fe_2O_3) or black (Fe_3O_4)



- **Zinc oxide:** white (ZnO)



- **Magnesium oxide:** white (MgO)



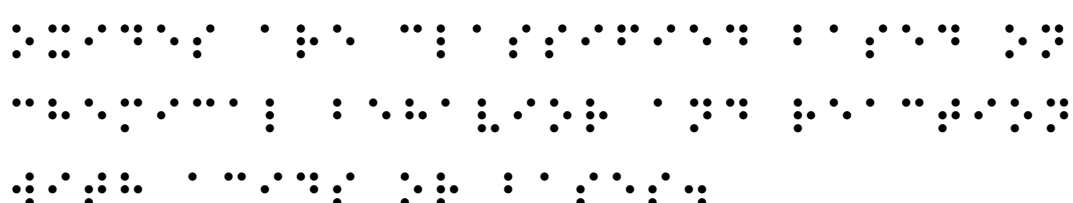
- **Sulfur oxides:** colourless gases (SO_2 , SO_3)



Summary:



- Oxides are classified based on **chemical behavior** and **reaction with acids or bases**.



- **Basic, acidic, amphoteric, and peroxides** cover most types.



- Their **industrial importance** and **physical properties** such as colour help in identification and usage.



Figure 1.1: Methods of gas collection
The following apparatus are used to collect gases:

Methods of gas collection

The following apparatus are used to collect gases:

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The following apparatus are used to collect gases:

- Gas jar

The gas jar is used to collect gases.

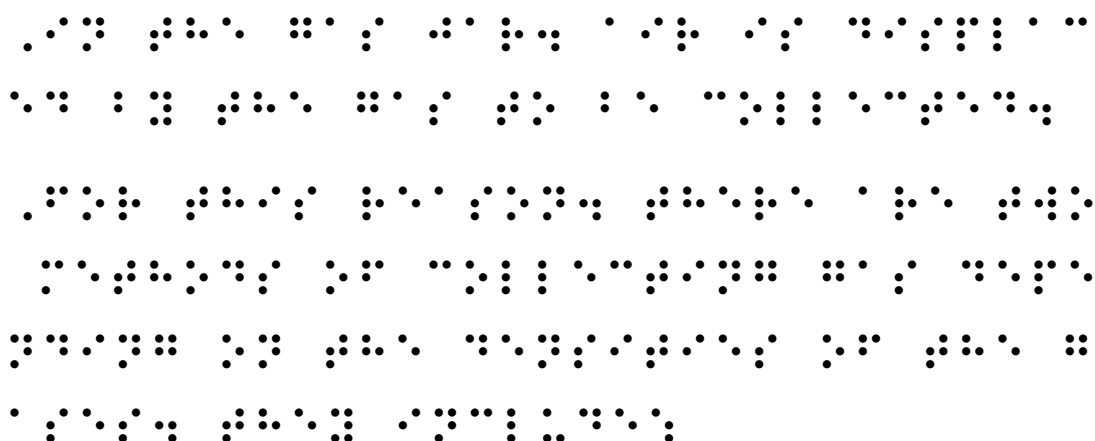
- Bee-hive stand

The bee-hive stand is used to hold the gas jar.

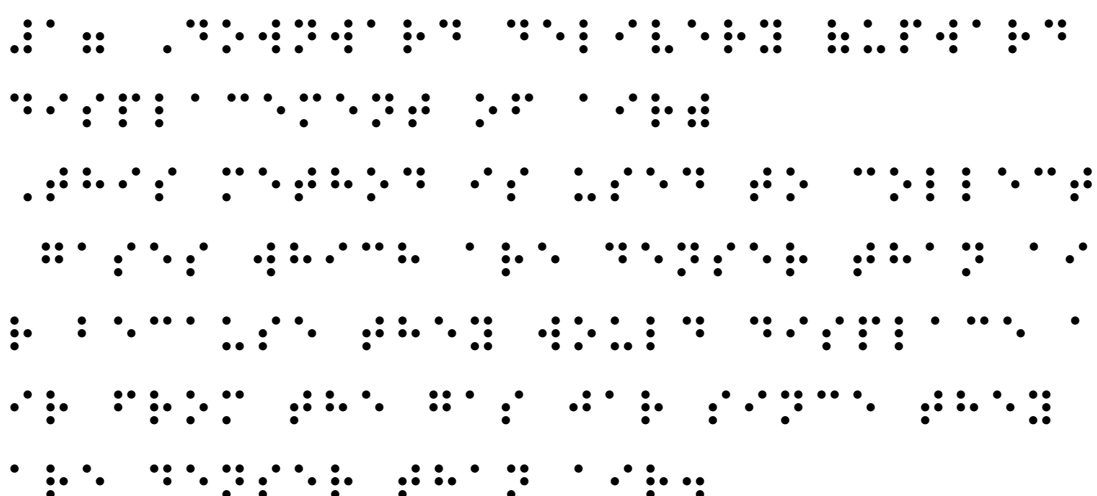
- Water trough



In the gas jar, air is displaced by the gas to be collected. For this reason, there are two methods of collecting gas depending on the densities of the gases. They include:



1. Downward delivery (upward displacement of air). This method is used to collect gases which are denser than air because they would displace air from the gas jar since they are denser than air.



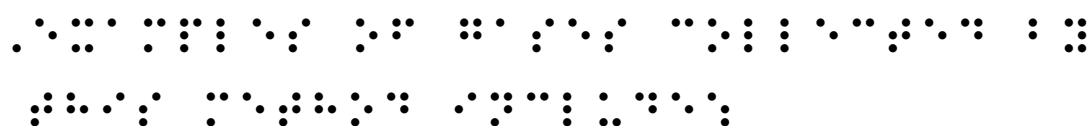
2) Upward delivery (downward displacement of air).

Diagram illustrating the setup for upward delivery (downward displacement of air). A gas jar is inverted over a trough of water. A delivery tube is inserted into the gas jar, with its end near the bottom. Gas is collected by displacing the water.

This method is used to collect gases which are less dense than air.

Diagram illustrating the setup for upward delivery (downward displacement of air). A gas jar is inverted over a trough of water. A delivery tube is inserted into the gas jar, with its end near the bottom. Gas is collected by displacing the water.

Examples of gases collected by this method include:



- Oxygen gas



- Hydrogen gas



- Nitrogen gas



- Carbon monoxide gas



- Ammonia gas



How to dry a gas



This is the process of removing suspended water vapour molecules from the gas collected.

. 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040

The following chemicals can be used to dry gases:

The Braille representation of the sentence "The cat sat on the mat." consists of two rows of dots. The first row contains the words "The", "cat", "sat", "on", "the", "mat.", and the second row contains the word "The".

Anhydrous calcium chloride.

• • • • •

It is used to dry all gases except ammonia gas because it reacts with it, forming a complex.

[illegible]

During the process, the anhydrous calcium chloride is put in a U-tube and the wet gas is passed through it.

. 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040

Concentrated Sulfuric acid

Concentrated sulphuric acid has no water. This acid is used to dry all gases except ammonia because it reacts with it to form ammonium sulphate.

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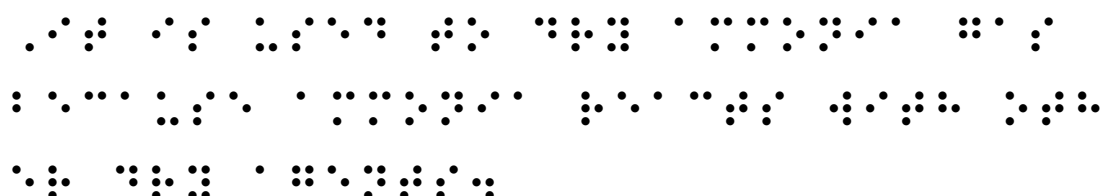
During this process, the acid is put in a wash bottle and the gas is passed through the acid where it is dried.

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Calcium oxide (quick lime).

Calcium oxide (quick lime).

It is used to dry ammonia gas because ammonia reacts with other dry agents.



WATER AND HYDROGEN

Water and hydrogen are fundamental to life and chemistry, and understanding them equips learners with knowledge that applies in daily life, industry, and scientific research.

Why it is necessary to study water and hydrogen

Water and hydrogen are fundamental to life and chemistry, and understanding them equips learners with knowledge that applies in daily life, industry, and scientific research.

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Water is essential for life: it makes up a large part of living organisms and is involved in biological reactions, digestion,

transport of nutrients, and temperature regulation.

Water is a polar molecule, meaning it has a partial positive charge on the hydrogen atoms and a partial negative charge on the oxygen atom. This polarity allows water molecules to form hydrogen bonds with each other, which is responsible for many of its unique properties, such as its high boiling point and its ability to act as a universal solvent.

Hydrogen is a basic element in chemistry: studying its reactions helps learners understand combustion, reduction, and acid-base chemistry.

Hydrogen is the most abundant element in the universe and is a key component of many chemical reactions. It is used in a variety of industrial processes, including the production of ammonia, methanol, and hydrogen gas. Hydrogen is also a clean energy source, as it can be used in fuel cells to generate electricity without producing greenhouse gases.

Practical and industrial applications: knowledge of water and hydrogen is key in water purification, energy generation, and chemical manufacturing.

Water and hydrogen are essential for life and have many practical and industrial applications. Water is used in a wide range of industries, from agriculture to manufacturing, and is a key component of many chemical reactions. Hydrogen is used in a variety of industrial processes, including the production of ammonia, methanol, and hydrogen gas. Hydrogen is also a clean energy source, as it can be used in fuel cells to generate electricity without producing greenhouse gases.

Developing scientific thinking: investigating water and hydrogen encourages learners to form hypotheses, design experiments,

and analyze results.

Chemical reactions are represented by chemical equations. In a chemical equation, the reactants are written on the left side of the equation, and the products are written on the right side. The equation is balanced when the number of atoms of each element is the same on both sides. This is done by adding coefficients in front of the chemical formulas.

Connection to sustainability and innovation: understanding hydrogen and water is crucial for sustainable technologies such as hydrogen fuel cells, desalination, and eco-friendly chemical processes.

Hydrogen and water are two of the most important substances in chemistry. They are both simple molecules, but they play a central role in many chemical reactions. Hydrogen is a clean-burning fuel, and water is a universal solvent. Understanding the properties and reactions of these two substances is essential for many areas of chemistry, including environmental science, materials science, and energy research.

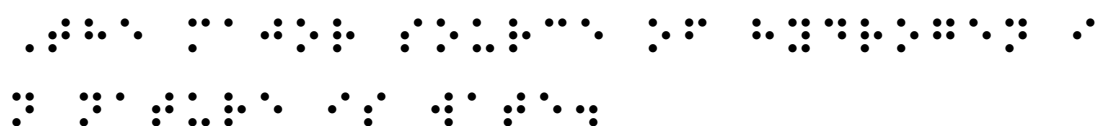
Foundation for advanced chemistry: water and hydrogen form the basis for learning about acids, bases, salts, and redox reactions.

Water and hydrogen are also important in the study of acids and bases. Acids are substances that donate protons (H⁺), and bases are substances that accept protons. Water can act as both an acid and a base, and it is the medium in which most acid-base reactions take place. Hydrogen is also a key component in many redox reactions, where electrons are transferred between species.

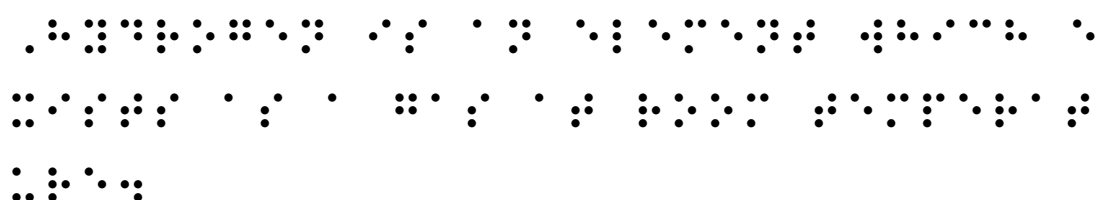
Hydrogen gas



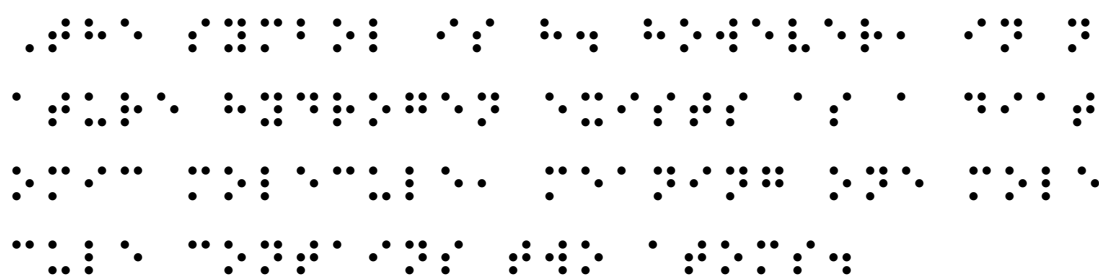
The major source of hydrogen in nature is water.



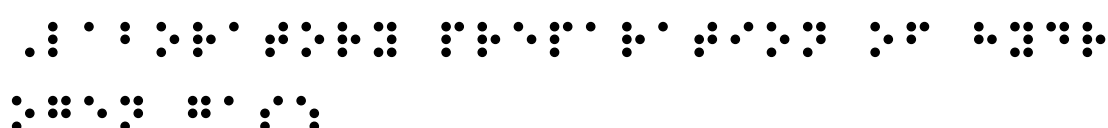
Hydrogen is an element which exists as a gas at room temperature.



The symbol is. However, in nature, hydrogen exists as diatomic molecule meaning one molecule contains two atoms.



Laboratory preparation of hydrogen gas



Requirements for preparing hydrogen gas in the laboratory

Requirements for preparing hydrogen gas in the laboratory

- Zinc granules

Zinc granules

- Dilute hydrochloric acid

Dilute hydrochloric acid

- Copper(II) sulphate

Copper(II) sulphate

- Flask

Flask

- Anhydrous calcium chloride

Anhydrous calcium chloride

- Gas jar

Gas jar

- U-tube

U-tube

- Delivery tube

• $\text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2$

Procedure for preparing hydrogen gas in the laboratory

1. Zinc granules are put in a flask fitted with a tap funnel. Hydrochloric acid is added to the flask. The whole set-up is connected with a U-tube and a gas jar.

- Zinc granules are put in a flask fitted with a tap funnel.

2. Hydrochloric acid is added to the flask. The whole set-up is connected with a U-tube and a gas jar.

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3. Dilute hydrochloric acid is slowly added to the zinc granules in the flask by opening the tap. Immediately, hydrogen gas is produced. This gas is seen as colorless bubbles.

- Dilute hydrochloric acid is slowly added to the zinc granules in the flask by opening the tap. Immediately, hydrogen gas is produced. This gas is seen as colorless bubbles.

4. The gas is collected in a gas jar by downward displacement of water.

The gas fills the flask and it is led out of the flask through a delivery tube to a U-tube containing anhydrous calcium chloride which dries the gas.

- The gas fills the flask and it is led out of the flask through a delivery tube to a U-tube containing anhydrous calcium chloride which dries the gas.

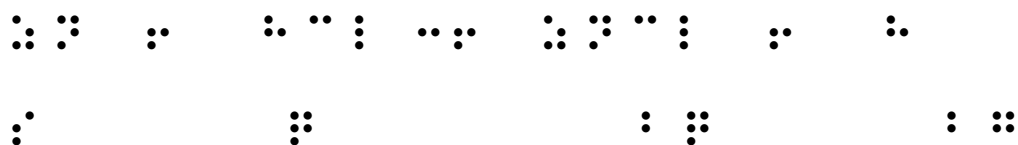
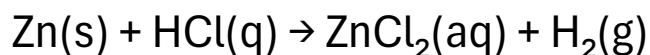
This gas is collected by upwards delivery (downward displacement of air) since it is less dense than air.

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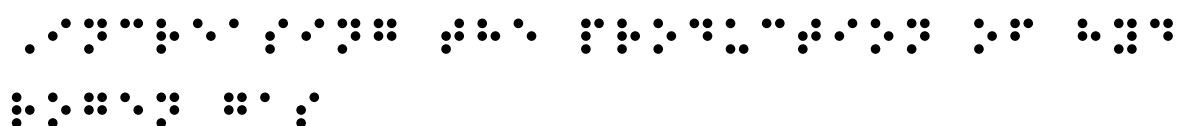
The gas is collected by upwards delivery (downward displacement of air) since it is less dense than air.

Equation:

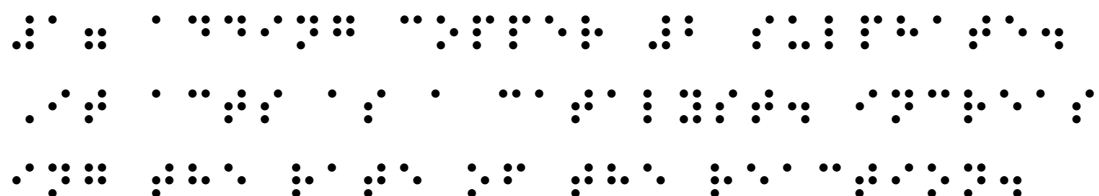




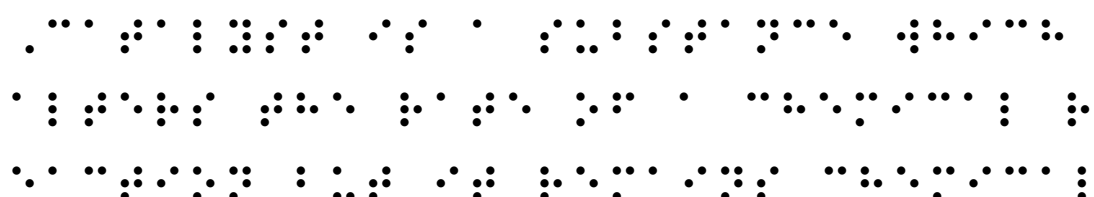
Increasing the production of hydrogen gas



1. Adding copper(II) sulphate. It acts as a catalyst, increasing the rate of the reaction.



Catalyst is a substance which alters the rate of a chemical reaction but it remains chemically unchanged at the end of the reaction.



$\text{Zn} + 2\text{H}^+ \rightarrow \text{Zn}^{2+} + \text{H}_2$
 $\text{Zn} + \text{H}_2\text{SO}_4 \rightarrow \text{ZnSO}_4 + \text{H}_2$

2. Using zinc powder instead of zinc granules. The zinc powder has a greater surface area than the zinc granules, hence more molecules would react to produce hydrogen gas.

$\text{Zn} + 2\text{H}^+ \rightarrow \text{Zn}^{2+} + \text{H}_2$
 $\text{Zn} + \text{H}_2\text{SO}_4 \rightarrow \text{ZnSO}_4 + \text{H}_2$
 $\text{Zn} + \text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2$
 $\text{Zn} + \text{HNO}_3 \rightarrow \text{Zn(NO}_3)_2 + \text{H}_2$

Testing for hydrogen gas

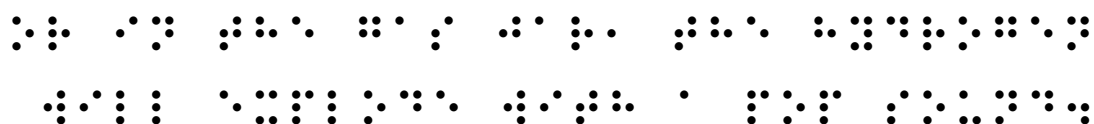
$\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}$

Hydrogen is tested by using a lighted splint.

$\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}$
 $\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}$

When a lighted splint is brought in close contact with hydrogen gas, either in the test tube or in the gas jar, the hydrogen will explode with a pop sound.

$\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}$
 $\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}$
 $\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}$



Physical properties of hydrogen

Physical properties of hydrogen

- Hydrogen is a colourless gas.



- Hydrogen is the lightest gas known.



- It is insoluble in water.



- Hydrogen is odourless (has no smell).



- Hydrogen is a neutral gas, i.e., it's neither acidic nor alkaline.

Hydrogen gas is used in the following ways:

Uses of hydrogen gas

Hydrogen gas is used in the following ways:

- Hydrogen is used in filling air balloons because it's the lightest gas.

Hydrogen gas is used in the following ways:

- Hydrogen is used in the hardening of oil, a process called hydrogenation. During this process, oil is converted to margarine by reacting it with hydrogen in the presence of a catalyst called nickel at 180°C and 2 atm [pressure]. The oil absorbs hydrogen to form fats.

Hydrogen gas is used in the following ways:

Hydrogen is a colorless, odorless, and tasteless gas. It is the lightest and most abundant element in the universe. It is used in the manufacture of ammonia, methanol, and other chemicals. It is also used in the hydrogenation of oils and in the production of electricity.

- It's used in the manufacture of petrol from coal.

Hydrogen is a colorless, odorless, and tasteless gas. It is the lightest and most abundant element in the universe. It is used in the manufacture of ammonia, methanol, and other chemicals. It is also used in the hydrogenation of oils and in the production of electricity.

- Hydrogen is used in the manufacture of a gas called ammonia in a process called the Haber process. Ammonia is an important gas because it is used in the manufacture of fertilizers, nitric acid, and explosives. During this process, hydrogen is reacted with nitrogen gas to give ammonia in the presence of iron as a catalyst.

Hydrogen is a colorless, odorless, and tasteless gas. It is the lightest and most abundant element in the universe. It is used in the manufacture of ammonia, methanol, and other chemicals. It is also used in the hydrogenation of oils and in the production of electricity. Hydrogen is used in the manufacture of ammonia in a process called the Haber process. Ammonia is an important gas because it is used in the manufacture of fertilizers, nitric acid, and explosives. During this process, hydrogen is reacted with nitrogen gas to give ammonia in the presence of iron as a catalyst.

Hydrogen gas is used in the manufacture of ammonia. In this process, hydrogen is reacted with nitrogen to form ammonia.

- It's used in the manufacture of hydrochloric acid. In this process, hydrogen is reacted with chlorine to form hydrochloric acid.

Hydrogen gas is used in the manufacture of hydrochloric acid. In this process, hydrogen is reacted with chlorine to form hydrochloric acid.

Industrial preparation of hydrogen gas

On a large scale, hydrogen gas is manufactured by the Bosch process.

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The raw materials used include coke and steam.

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Steam is passed over hot coke to form carbon monoxide and hydrogen gas.

Steam is passed over hot coke to form carbon monoxide and hydrogen gas.

Water gas is a mixture of carbon monoxide and hydrogen gas. It is used in the production of synthetic natural gas.

A combination of carbon monoxide and hydrogen gas is water gas.

Water gas is a mixture of carbon monoxide and hydrogen gas. It is used in the production of synthetic natural gas.

The carbon monoxide is absorbed in another chemical, leaving hydrogen gas behind.

Water gas is a mixture of carbon monoxide and hydrogen gas. It is used in the production of synthetic natural gas.

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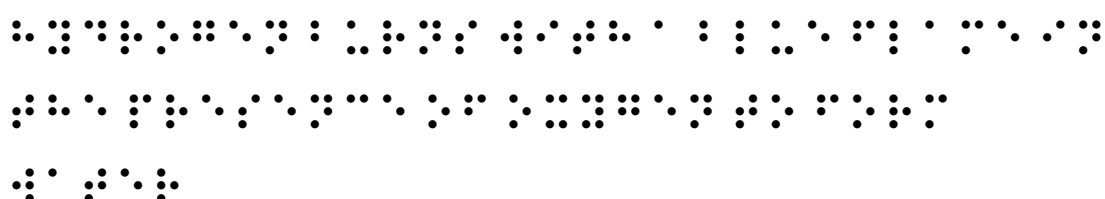
Chemical properties of hydrogen gas

Hydrogen gas is a colorless, odorless, and tasteless gas. It is highly flammable and reacts with oxygen to form water.

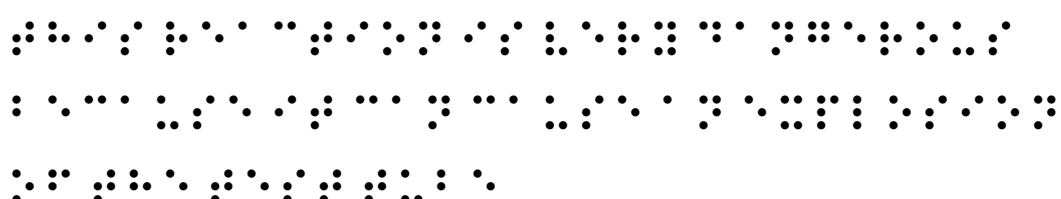
a) Reaction of hydrogen gas with oxygen

Hydrogen gas reacts with oxygen to form water. The reaction is exothermic, meaning it releases heat.

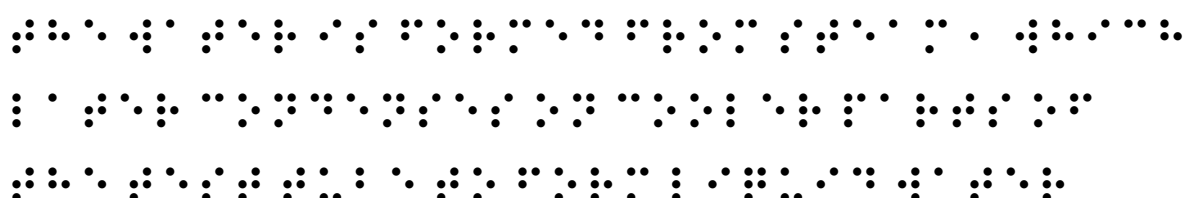
Hydrogen burns with a blue flame in the presence of oxygen to form water.



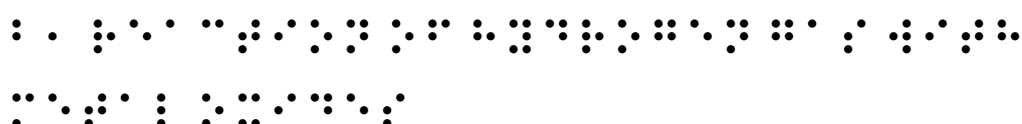
This reaction is very dangerous because it can cause an explosion of the test tube.

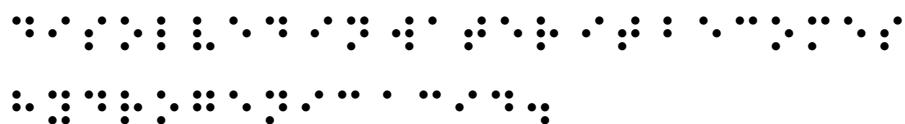


The water is formed from steam, which later condenses on cooler parts of the test tube to form liquid water.

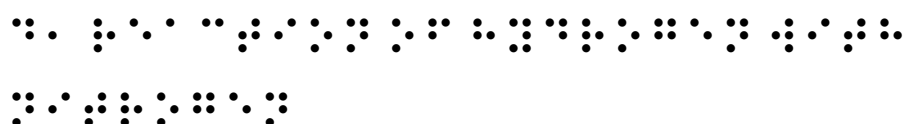


b) Reaction of hydrogen gas with metal oxides

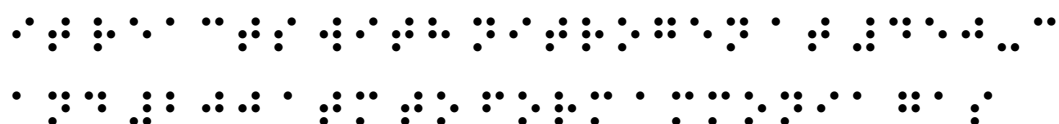




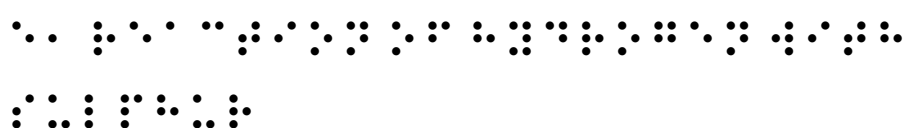
d) Reaction of hydrogen with nitrogen



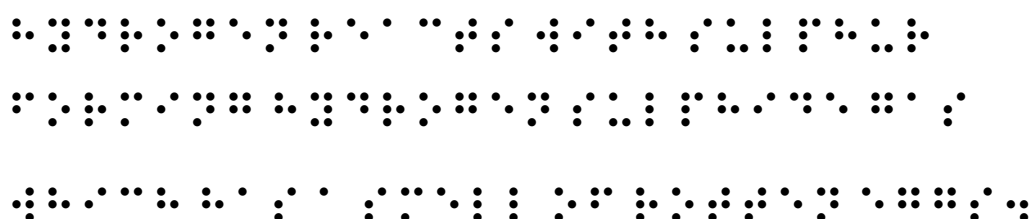
It reacts with nitrogen at 450°C and 200 atm to form ammonia gas.



e) Reaction of hydrogen with sulphur



Hydrogen reacts with sulphur forming hydrogen sulphide gas which has a smell of rotten eggs.



[illegible]

a) Rain water

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This water is fairly pure although it contains dissolved gases from the atmosphere e.g oxygen and carbondioxide. It also contains dust particles.

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b) Spring water

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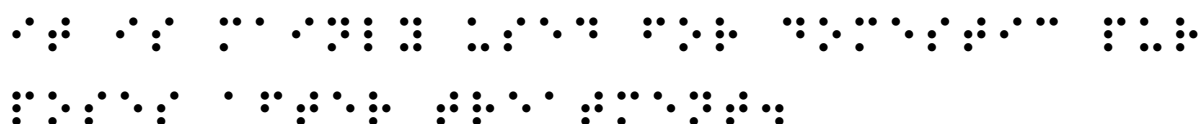
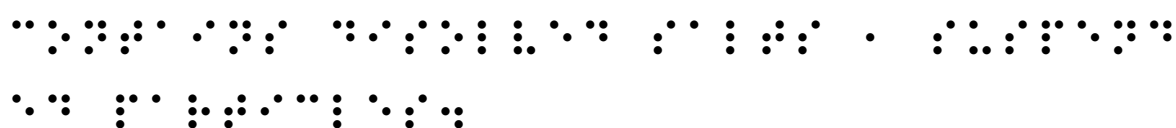
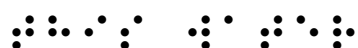
The water originates from the rocks underground. This water contains a number of dissolved minerals such as iron , calcium etc

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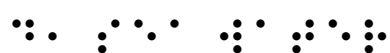
c) River water



This water contains dissolved salts, suspended particles. It is mainly used for domestic purposes after treatment



d) Sea water



This water contains more dissolved salts than any other sources of water. These salts include sodium chloride, magnesium chloride, calcium chloride, calcium sulphate, etc. The presence of these salts makes sea water very dense and salty. Sea water is a major source of a number of elements and compounds e.g. bromine, potassium, sodium, etc.



Water cycle diagram showing the process of evaporation, condensation, precipitation, and collection.

Water cycle

Water cycle diagram showing the process of evaporation, condensation, precipitation, and collection.

The water cycle shows how water circulates around the Earth.

Water cycle diagram showing the process of evaporation, condensation, precipitation, and collection.

The cycle begins when the sun evaporates water from seas, oceans, lakes, and rivers.

Water cycle diagram showing the process of evaporation, condensation, precipitation, and collection.

The water vapor rises to the atmosphere where it cools to form the rain clouds.

Water vapor rises into the atmosphere where it cools and condenses to form rain clouds. The rain clouds are made of tiny water droplets that have condensed together.

The rain clouds further cool, and at a certain temperature they turn into droplets which fall on the Earth's surface in the form of rainfall.

The rain clouds are made of tiny water droplets that have condensed together. The rain clouds are made of tiny water droplets that have condensed together. The rain clouds are made of tiny water droplets that have condensed together.

The rainwater then runs into streams and rivers, where it is taken to the lakes and seas.

The rainwater then runs into streams and rivers, where it is taken to the lakes and seas. The rainwater then runs into streams and rivers, where it is taken to the lakes and seas.

Physical properties of water

Water has several physical properties.

- Water is a liquid at room temperature

At room temperature, water is a liquid. It is not a solid or a gas. It can flow and take the shape of its container.

- Water is a colourless liquid

Water is a colourless liquid. It does not have any colour. It is transparent and you can see through it.

- Has no smell

Water has no smell. It is odourless and you cannot smell it.

- Water is tasteless substance i.e. it has flat taste.

Water is a tasteless substance. It has a flat taste and you cannot taste it. It is not sweet, sour, or salty.

- Pure water boils at 100c

Pure water boils at 100 degrees Celsius. When heated to this temperature, it turns into a gas (steam).

- Water has a density of 1g/dm^3 at 4°C

Water is a liquid at room temperature and has a density of 1g/dm^3 at 4°C . It is a neutral compound and its pH is 7.

- Water is neutral compound i.e. it is neither acidic nor alkaline compound

Water is a neutral compound, meaning it is neither acidic nor alkaline. It has a pH of 7 and is a liquid at room temperature.

- Water has a PH of 7.

Water is a neutral compound and its pH is 7.

NB// it is pleasant to drink water which contains dissolved gases or solids because they give water its taste

Water is a liquid at room temperature and has a density of 1g/dm^3 at 4°C . It is a neutral compound and its pH is 7. Water is a liquid at room temperature and has a density of 1g/dm^3 at 4°C . It is a neutral compound and its pH is 7.

How to test for water in the laboratory

Water is a liquid at room temperature and has a density of 1g/dm^3 at 4°C . It is a neutral compound and its pH is 7.

Water turns the white colour of Anhydrous copper(II)sulphate to blue.

$\frac{1}{2} \cdot \frac{1}{2} = \frac{1}{4}$

Anhydrous Cobalt(II)chloride paper



This paper is made by soaking it in a solution of cobalt(II)chloride.

[illegible]

The paper is then dried using a Bunsen burner .this paper turns from blue to pink when put in water.












Water is a liquid at room temperature. It is a colorless, odorless, and tasteless substance. It is the most abundant substance on Earth. It is essential for life. It is a good solvent. It is a good conductor of heat. It is a good conductor of electricity. It is a good conductor of sound. It is a good conductor of light. It is a good conductor of radio waves. It is a good conductor of microwaves. It is a good conductor of infrared radiation. It is a good conductor of ultraviolet radiation. It is a good conductor of gamma rays. It is a good conductor of X-rays. It is a good conductor of alpha particles. It is a good conductor of beta particles. It is a good conductor of neutrons. It is a good conductor of protons. It is a good conductor of electrons. It is a good conductor of positrons. It is a good conductor of neutrinos. It is a good conductor of antineutrinos. It is a good conductor of all particles.

Water in the Atmosphere

Water is present in the atmosphere in the form of water vapor, clouds, and precipitation.

Deliquescence

Deliquescence is the process by which a solid substance absorbs water vapor from the atmosphere and changes to a liquid or solution.

- This is the absorption of water vapor from the atmosphere by a solid to form a solution.

Deliquescent substances are those which absorb water vapor from the atmosphere and change to a liquid or solution. Some common deliquescent substances are calcium chloride, magnesium chloride, and sodium chloride. These substances are used in a variety of applications, including as drying agents, in the production of chemicals, and in the treatment of water.

- Substances which absorb water vapor from the atmosphere and change to a liquid or solution are called deliquescent.

Deliquescent substances are those which absorb water vapor from the atmosphere and change to a liquid or solution. Some common deliquescent substances are calcium chloride, magnesium chloride, and sodium chloride. These substances are used in a variety of applications, including as drying agents, in the production of chemicals, and in the treatment of water.

- The substance absorbing water vapor simply becomes damp or wet.

[illegible]

- Examples of hygroscopic substances:

[illegible]

- Calcium oxide (quick lime)

A 5x5 grid of dots forming the letters 'MATHS'. The letters are constructed using black dots on a white background. 'M' is formed by dots at (1,1), (1,2), (1,4), (1,5), (2,1), (2,2), (2,4), (2,5), (3,1), (3,2), (3,4), (3,5), (4,1), (4,2), (4,4), (4,5), and (5,1), (5,2), (5,4), (5,5). 'A' is formed by dots at (1,3), (2,3), (3,3), (4,3), (5,3), (2,4), (3,4), (4,4), (2,5), (3,5), (4,5). 'T' is formed by dots at (1,6), (2,6), (3,6), (4,6), (5,6), (3,7), (3,8), (3,9), (3,10), (3,11). 'H' is formed by dots at (1,12), (2,12), (3,12), (4,12), (5,12), (1,13), (2,13), (3,13), (4,13), (5,13), (1,14), (2,14), (3,14), (4,14), (5,14), (1,15), (2,15), (3,15), (4,15), (5,15). 'S' is formed by dots at (1,16), (2,16), (3,16), (4,16), (5,16), (1,17), (2,17), (3,17), (4,17), (5,17), (1,18), (2,18), (3,18), (4,18), (5,18), (1,19), (2,19), (3,19), (4,19), (5,19), (1,20), (2,20), (3,20), (4,20), (5,20).

- Copper(II) oxide

- Concentrated sulphuric acid

THE UNIVERSITY OF CHICAGO

- Anhydrous copper(II) sulphate

• **2019** • **2020** • **2021** • **2022** • **2023** • **2024** • **2025** • **2026** • **2027** • **2028** • **2029** • **2030** • **2031** • **2032** • **2033** • **2034** • **2035** • **2036** • **2037** • **2038** • **2039** • **2040** • **2041** • **2042** • **2043** • **2044** • **2045** • **2046** • **2047** • **2048** • **2049** • **2050** • **2051** • **2052** • **2053** • **2054** • **2055** • **2056** • **2057** • **2058** • **2059** • **2060** • **2061** • **2062** • **2063** • **2064** • **2065** • **2066** • **2067** • **2068** • **2069** • **2070** • **2071** • **2072** • **2073** • **2074** • **2075** • **2076** • **2077** • **2078** • **2079** • **2080** • **2081** • **2082** • **2083** • **2084** • **2085** • **2086** • **2087** • **2088** • **2089** • **2090** • **2091** • **2092** • **2093** • **2094** • **2095** • **2096** • **2097** • **2098** • **2099** • **2100** • **2101** • **2102** • **2103** • **2104** • **2105** • **2106** • **2107** • **2108** • **2109** • **2110** • **2111** • **2112** • **2113** • **2114** • **2115** • **2116** • **2117** • **2118** • **2119** • **2120** • **2121** • **2122** • **2123** • **2124** • **2125** • **2126** • **2127** • **2128** • **2129** • **2130** • **2131** • **2132** • **2133** • **2134** • **2135** • **2136** • **2137** • **2138** • **2139** • **2140** • **2141** • **2142** • **2143** • **2144** • **2145** • **2146** • **2147** • **2148** • **2149** • **2150** • **2151** • **2152** • **2153** • **2154** • **2155** • **2156** • **2157** • **2158** • **2159** • **2160** • **2161** • **2162** • **2163** • **2164** • **2165** • **2166** • **2167** • **2168** • **2169** • **2170** • **2171** • **2172** • **2173** • **2174** • **2175** • **2176** • **2177** • **2178** • **2179** • **2180** • **2181** • **2182** • **2183** • **2184** • **2185** • **2186** • **2187** • **2188** • **2189** • **2190** • **2191** • **2192** • **2193** • **2194** • **2195** • **2196** • **2197** • **2198** • **2199** • **2200** • **2201** • **2202** • **2203** • **2204** • **2205** • **2206** • **2207** • **2208** • **2209** • **2210** • **2211** • **2212** • **2213** • **2214** • **2215** • **2216** • **2217** • **2218** • **2219** • **2220** • **2221** • **2222** • **2223** • **2224** • **2225** • **2226** • **2227** • **2228** • **2229** • **2230** • **2231** • **2232** • **2233** • **2234** • **2235** • **2236** • **2237** • **2238** • **2239** • **2240** • **2241** • **2242** • **2243** • **2244** • **2245** • **2246** • **2247** • **2248** • **2249** • **2250** • **2251** • **2252** • **2253** • **2254** • **2255** • **2256** • **2257** • **2258** • **2259** • **2260** • **2261** • **2262** • **2263** • **2264** • **2265** • **2266** • **2267** • **2268** • **2269** • **2270** • **2271** • **2272** • **2273** • **2274** • **2275** • **2276** • **2277** • **2278** • **2279** • **2280** • **2281** • **2282** • **2283** • **2284** • **2285** • **2286** • **2287** • **2288** • **2289** • **2290** • **2291** • **2292** • **2293** • **2294** • **2295** • **2296** • **2297** • **2298** • **2299** • **2300** • **2301** • **2302** • **2303** • **2304** • **2305** • **2306** • **2307** • **2308** • **2309** • **2310** • **2311** • **2312** • **2313** • **2314** • **2315** • **2316** • **2317** • **2318** • **2319** • **2320** • **2321** • **2322** • **2323** • **2324** • **2325** • **2326** • **2327** • **2328** • **2329** • **2330** • **2331** • **2332** • **2333** • **2334** • **2335** • **2336** • **2337** • **2338** • **2339** • **2340** • **2341** • **2342** • **2343** • **2344** • **2345** • **2346** • **2347** • **2348** • **2349** • **2350** • **2351** • **2352** • **2353** • **2354** • **2355** • **2356** • **2357** • **2358** • **2359** • **2360** • **2361** • **2362** • **2363** • **2364** • **2365** • **2366** • **2367** • **2368** • **2369** • **2370** • **2371** • **2372** • **2373** • **2374** • **2375** • **2376** • **2377** • **2378** • **2379** • **2380** • **2381** • **2382** • **2383** • **2384** • **2385** • **2386** • **2387** • **2388** • **2389** • **2390** • <

Efflorescence

- These are substances which lose water of crystallization when exposed to the atmosphere.



- Examples of efflorescent substances:

- Hydrated sodium carbonate

Figure 6. The effect of the number of trials on the accuracy of the responses. The mean accuracy of the responses was plotted against the number of trials. The error bars represent the standard error of the mean.

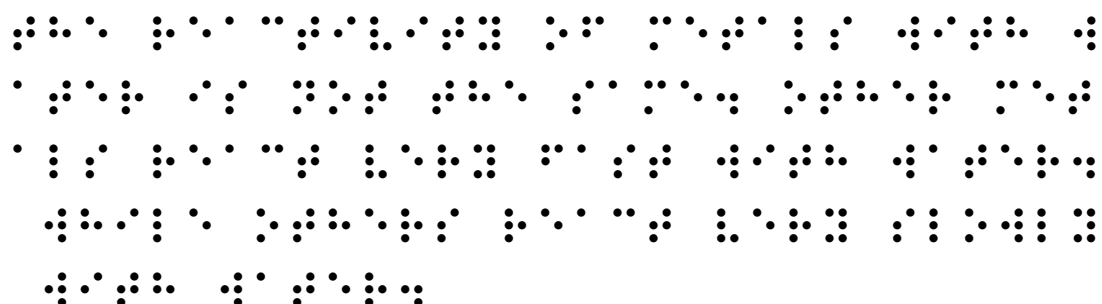
- Hydrated sodium sulphate

[illegible]

Action of Water



The reactivity of metals with water is not the same. Other metals react very fast with water, while others react very slowly with water.



Generally:



Metals + Water → Hydrogen gas + Metal hydroxide/metal oxide



The arrangement of the reactivity of metals with water, beginning from the most reactive to the least reactive, is called the reactivity series or activity series.

REACTIVITY SERIES OF METALS
The reactivity series of metals is a list of metals arranged in order of their reactivity. The most reactive metal is at the top and the least reactive metal is at the bottom. The reactivity series can be used to predict the products of a reaction between a metal and an acid or a salt solution.

The reactivity series is given below:

Most reactive metal
Least reactive metal

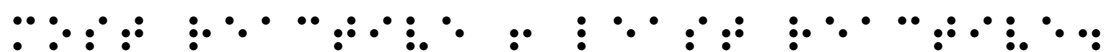
Reactivity Series of Metals with Water

Metals above hydrogen react with water to form a metal hydroxide and hydrogen gas.
Metals below hydrogen do not react with water.

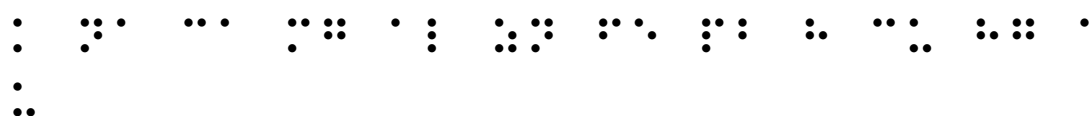
The reactivity series is the arrangement of metals according to their rate of reaction with water. It begins with the most reactive metal and ends with the least reactive metal.

REACTIVITY SERIES OF METALS
The reactivity series of metals is a list of metals arranged in order of their reactivity. The most reactive metal is at the top and the least reactive metal is at the bottom. The reactivity series can be used to predict the products of a reaction between a metal and an acid or a salt solution.

Most reactive → Least reactive:



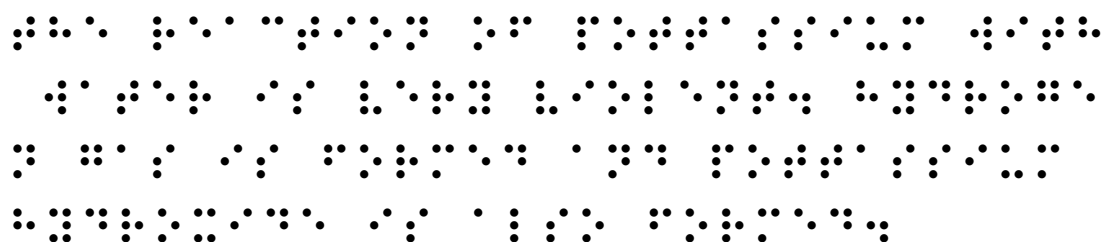
K, Na, Ca, Mg, Al, Zn, Fe, Pb, H, Cu, Hg, Ag, Au



Potassium



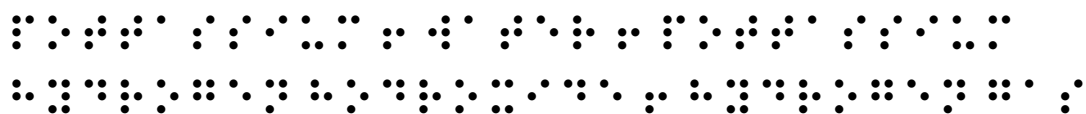
The reaction of potassium with water is very violent. Hydrogen gas is formed and potassium hydroxide is also formed.



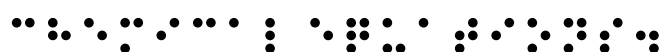
Reaction of Potassium with Water



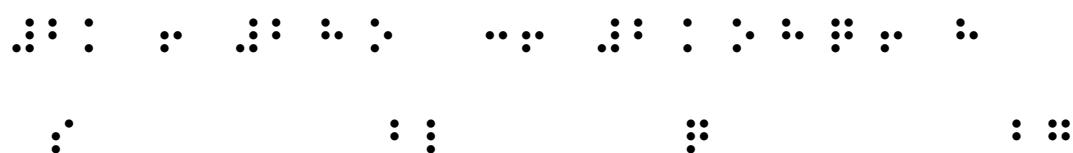
Potassium + Water → Potassium hydroxide + Hydrogen gas



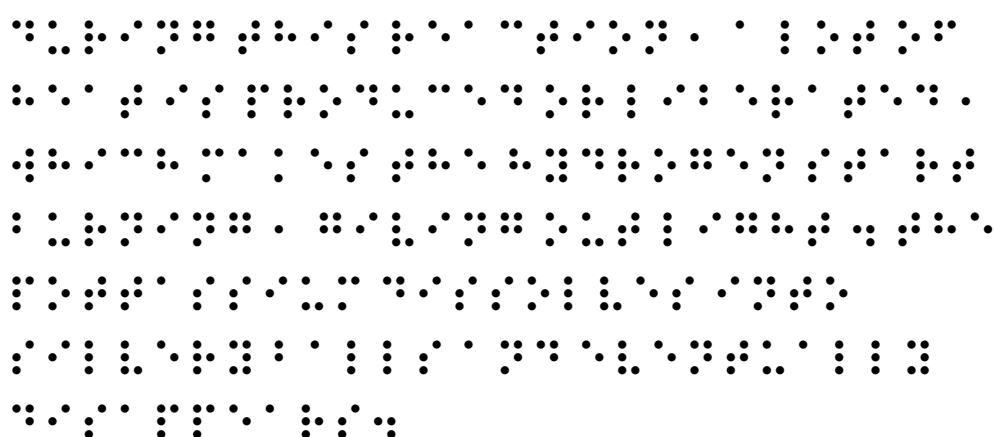
Chemical Equation:



2K(s) + 2H₂O(l) → 2KOH(aq) + H₂(g)



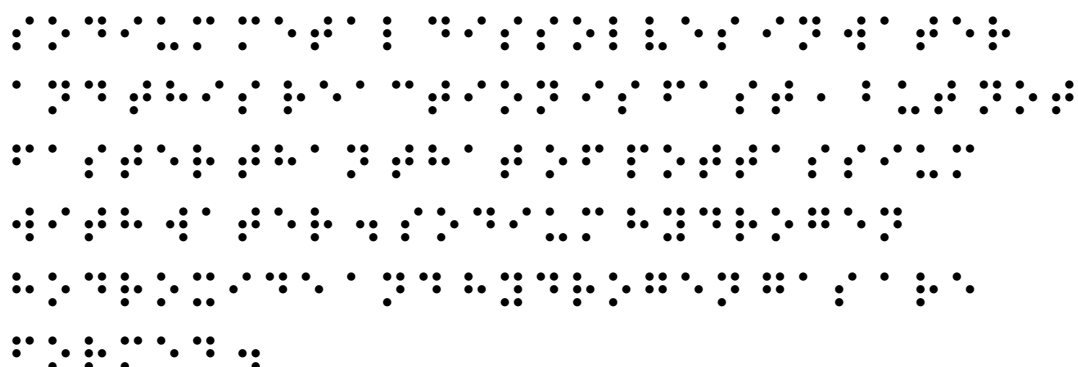
During this reaction, a lot of heat is produced or liberated, which makes the hydrogen start burning, giving out light. The potassium dissolves into silvery balls and eventually disappears.



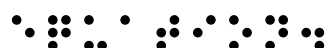
b) Sodium



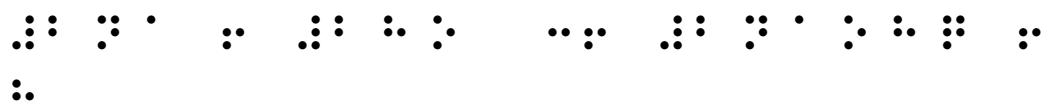
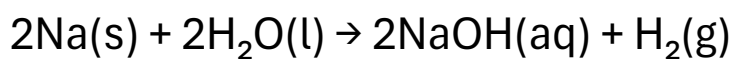
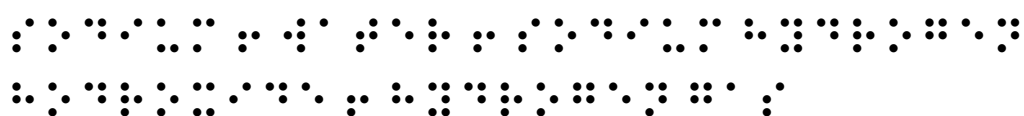
Sodium metal dissolves in water and this reaction is fast, but not faster than that of potassium with water. Sodium hydroxide and hydrogen gas are formed.



Equation:



Sodium + Water → Sodium hydroxide + Hydrogen gas



During the reaction, the sodium metal melts into silvery balls, but the hydrogen liberated does not burn like potassium; therefore, no heat and light are given out.

During the reaction, the sodium metal melts into silvery balls, but the hydrogen liberated does not burn like potassium; therefore, no heat and light are given out.

Storage Note:

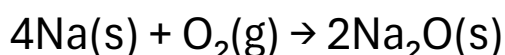
Na and K are very reactive elements. They are stored under oil to prevent contact with air.

Na and K are very reactive elements. They are stored under oil to prevent contact with air.

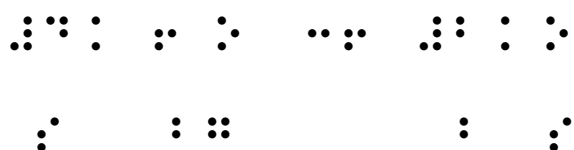
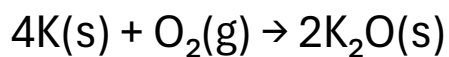
Na and K are very reactive elements. They are stored under oil to prevent contact with air.

Reaction with Oxygen:

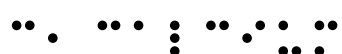
Reaction with Oxygen:



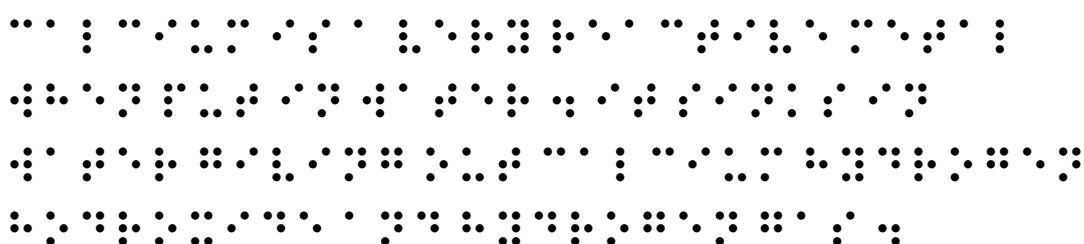
Reaction with Oxygen:



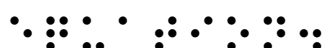
c) Calcium



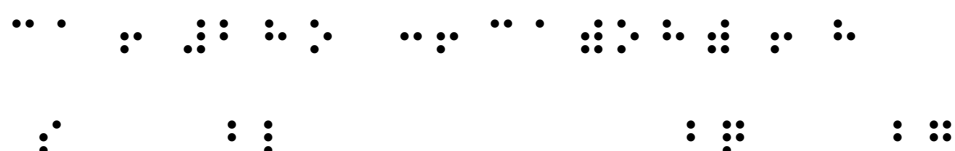
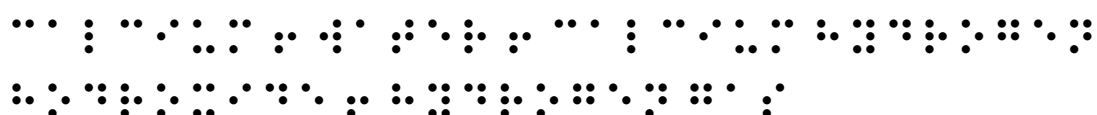
Calcium is a very reactive metal when put in water. It sinks in water giving out calcium hydroxide and hydrogen gas.



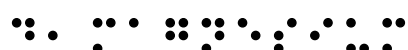
Equation:



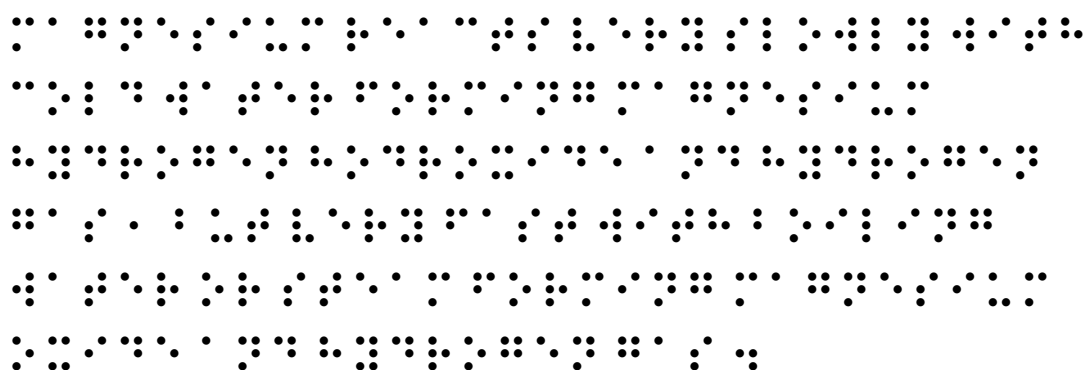
Calcium + Water → Calcium hydroxide + Hydrogen gas



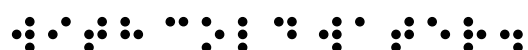
d) Magnesium



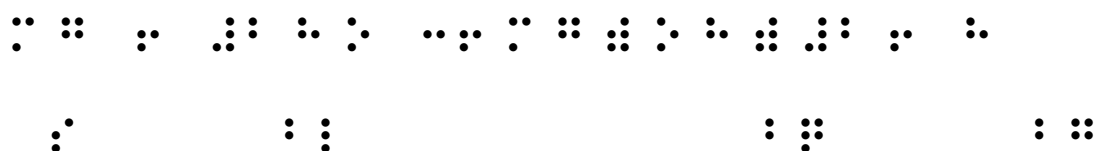
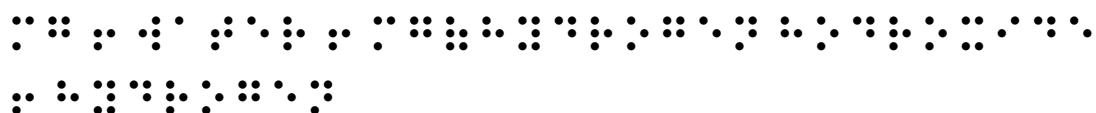
Magnesium reacts very slowly with cold water forming magnesium hydroxide and hydrogen gas, but very fast with boiling water or steam forming magnesium oxide and hydrogen gas.



With cold water:



Magnesium + Water → Magnesium hydroxide + Hydrogen gas



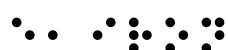
With steam or boiling water:



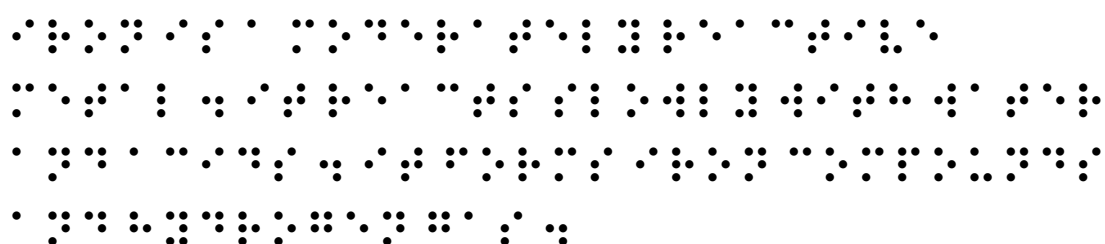
Magnesium + Steam → Magnesium oxide + Hydrogen gas



e) Iron



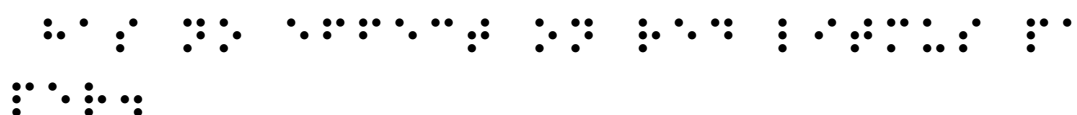
Iron is a moderately reactive metal. It reacts slowly with water and acids, forming iron compounds and hydrogen gas.



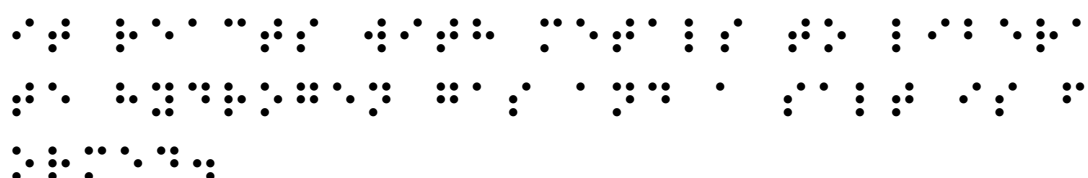
Rusting of Iron:

Iron rusts slowly when exposed to moist air over a long time. The presence of water and oxygen causes iron to corrode and form a reddish-brown flaky substance called rust. Rusting weakens iron objects and can destroy their strength over time. Preventing rust involves coating iron with paint, oil, or other protective layers, and keeping it away from moisture.

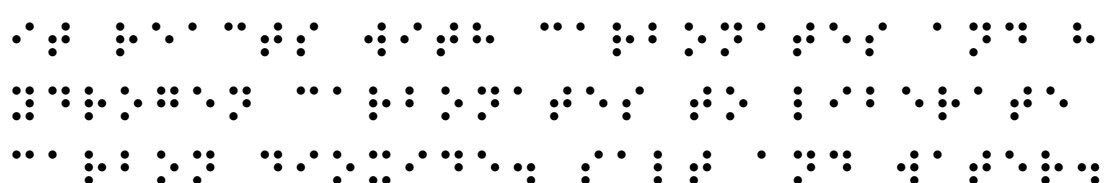
A 12x12 grid of black dots on a white background, representing a sparse matrix. The dots are arranged in a pattern that suggests a banded structure, with higher density along the main diagonal and some off-diagonal elements, particularly in the lower-left and upper-right quadrants.



- It reacts with metals to liberate hydrogen gas and a salt is formed.



- It reacts with carbonates and hydrogen carbonates to liberate carbon dioxide, salt and water.



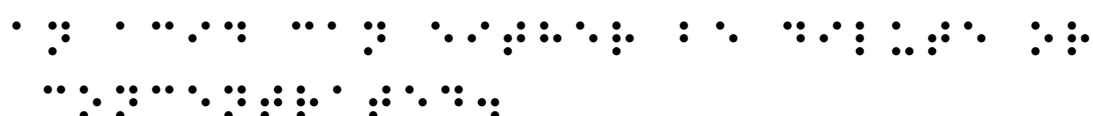
- It reacts with a base to form salt and water only.



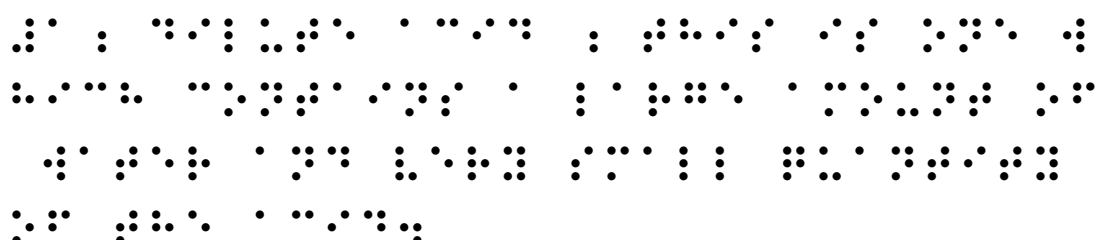
Concentration of acids

Acids are classified into two types.

An acid can either be dilute or concentrated.



1. Dilute acid – This is one which contains a large amount of water and very small quantity of the acid.



2. Concentrated acid – This contains a very large amount of acid dissolved in a little amount of water.

Brackets are used to show the amount of acid and water in a solution. For example, (100g acid / 10g water) is a concentrated acid solution. (10g acid / 100g water) is a dilute acid solution.

Strength of acid

The strength of an acid is determined by the number of hydrogen ions it produces when dissolved in water.

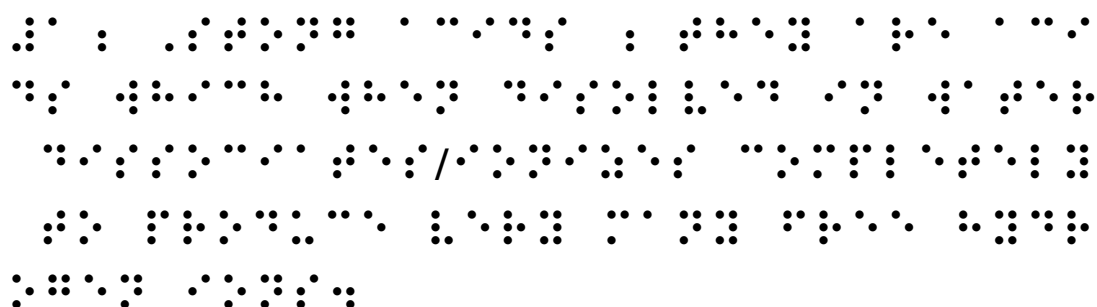
The strength of any acid is determined by the number or amount of hydrogen ions an acid can produce when dissolved in water i.e. some acids produce very many hydrogen ions while others produce very few hydrogen ions.

For example, hydrochloric acid (HCl) produces one hydrogen ion (H⁺) when dissolved in water. Sulfuric acid (H₂SO₄) produces two hydrogen ions (2H⁺) when dissolved in water. Nitric acid (HNO₃) produces one hydrogen ion (H⁺) when dissolved in water. Acetic acid (CH₃COOH) produces one hydrogen ion (H⁺) when dissolved in water. Carbonic acid (H₂CO₃) produces two hydrogen ions (2H⁺) when dissolved in water.

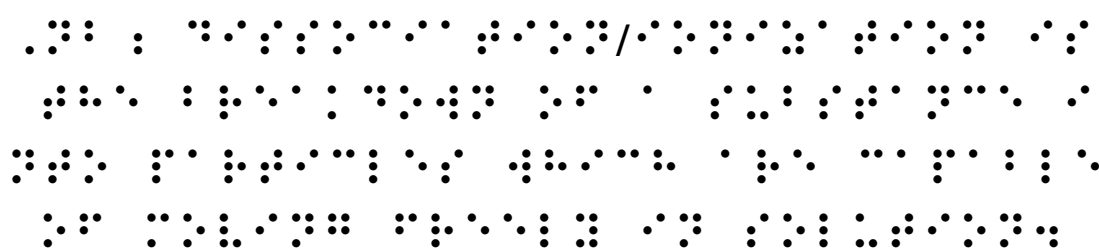
On this basis, acids are of two types:

1. Strong acids – These are acids that completely dissociate into hydrogen ions and anions in water. Examples include hydrochloric acid (HCl), sulfuric acid (H₂SO₄), and nitric acid (HNO₃).

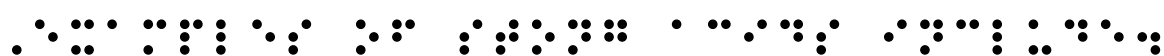
1. Strong acids – They are acids which when dissolved in water dissociates/ionizes completely to produce very many free hydrogen ions.



NB: Dissociation/ionisation is the breakdown of a substance into particles which are capable of moving freely in solution.



Examples of strong acids include:



- Sulphuric acid



- Nitric acid



- Hydrochloric acid



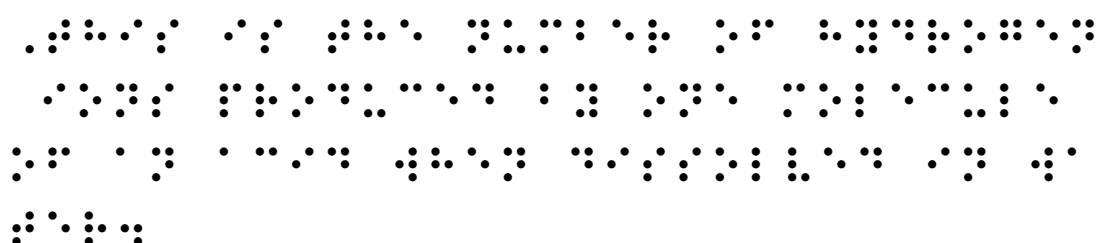
- Phosphoric acid



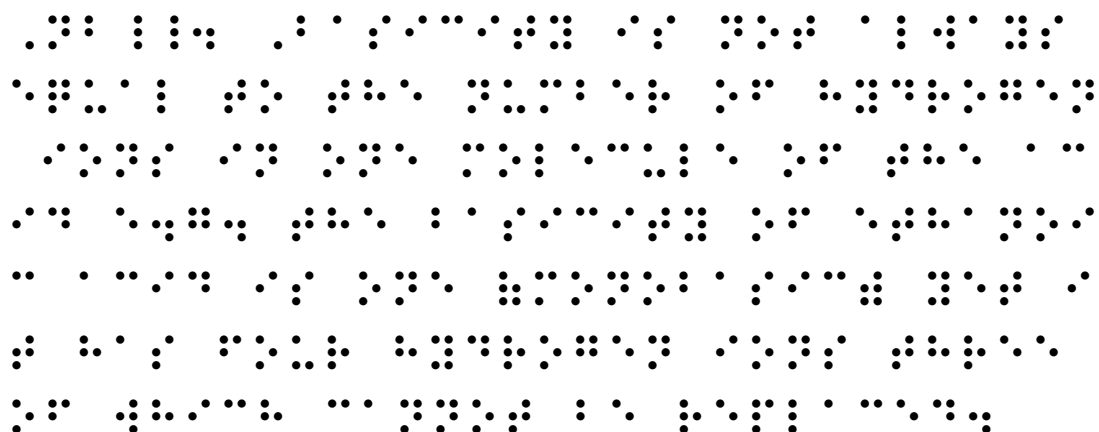
Basicity of an acid



This is the number of hydrogen ions produced by one molecule of an acid when dissolved in water.



NB//. Basicity is not always equal to the number of hydrogen ions in one molecule of the acid e.g. the basicity of ethanoic acid is one (monobasic) yet it has four hydrogen ions three of which cannot be replaced.



Some acids produce 2, 3 or more hydrogen ions per molecule.

For example, sulphuric acid produces two hydrogen ions per molecule.

Types of basicity

There are two types of basicity.

(a) Monobasic acid. It is an acid which dissociates to produce only one hydrogen ion when dissolved in water. The acid is said to have a basicity of one e.g.

Hydrochloric acid dissociates to produce one hydrogen ion per molecule.

Hydrochloric acid

Cl

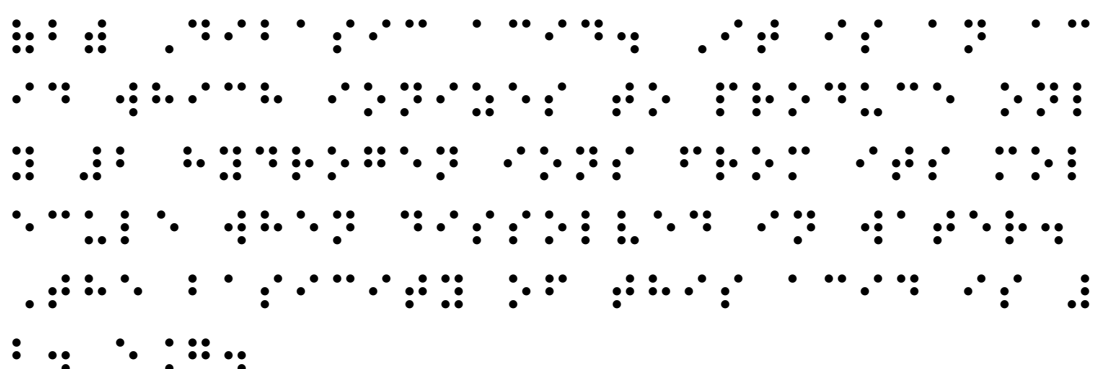
Nitric acid

NO3

Ethanoic acid



(b) Dibasic acid. It is an acid which ionizes to produce only two hydrogen ions from its molecule when dissolved in water. The basicity of this acid is two. E.g.



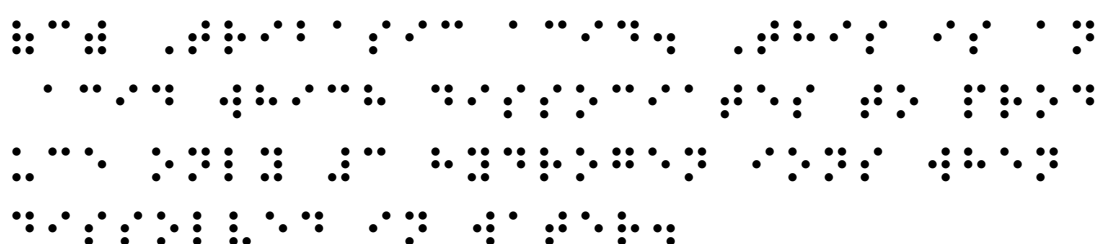
Sulphuric acid



Carbonic acid



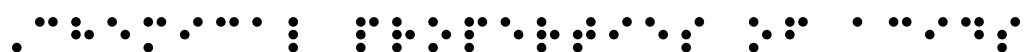
(c) Tribasic acid. This is an acid which dissociates to produce only three hydrogen ions when dissolved in water. E.g.



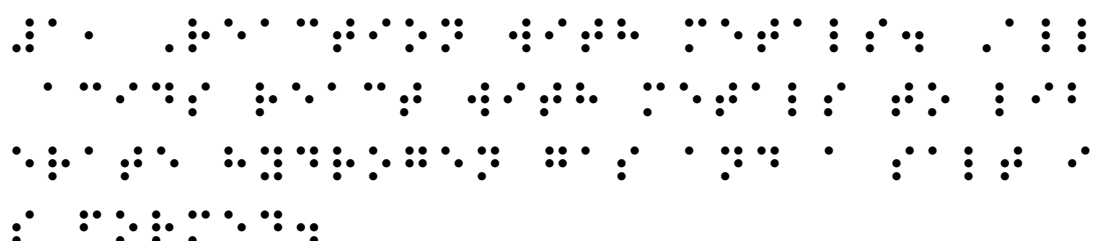
Phosphoric acid



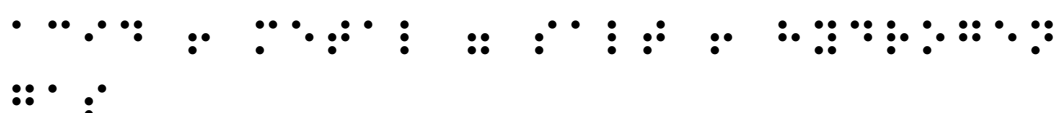
Chemical properties of acids



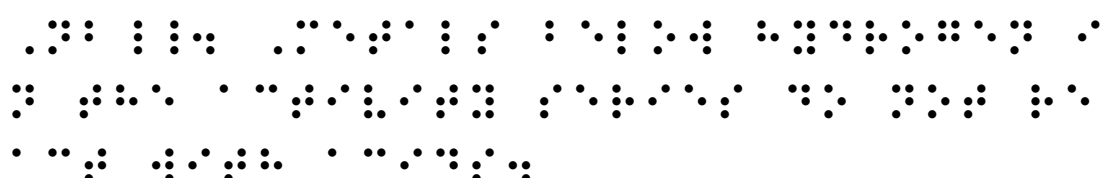
1) Reaction with metals. All acids react with metals to liberate hydrogen gas and a salt is formed.



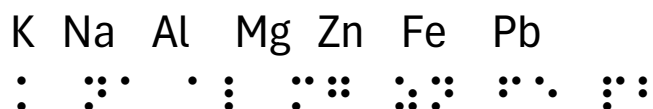
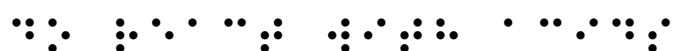
Acid + metal $\rightarrow$ salt + hydrogen gas



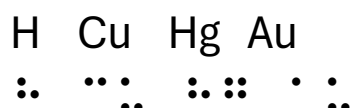
NB//. Metals below hydrogen in the activity series do not react with acids.



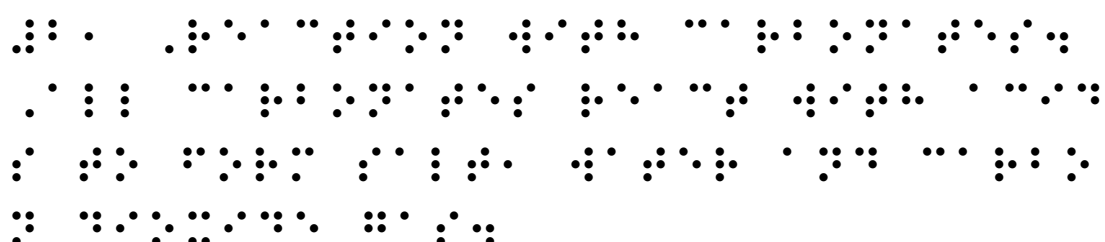
Do react with acids:



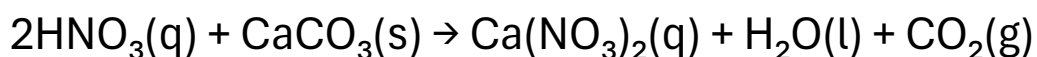
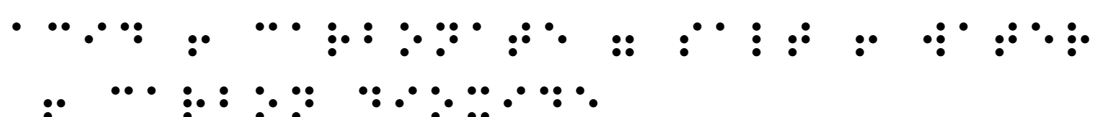
Do not react with acids:

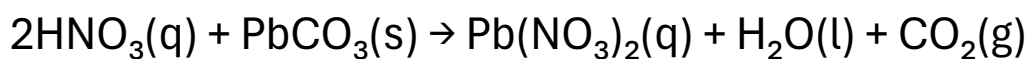
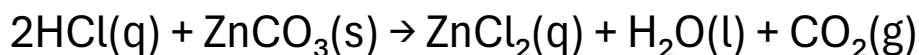
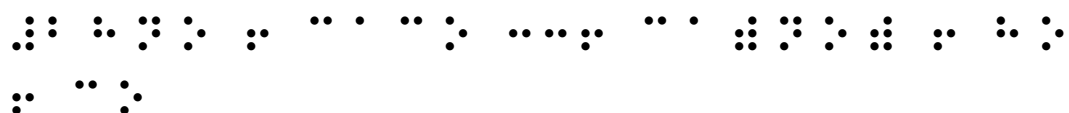


2) Reaction with carbonates. All carbonates react with acids to form salt, water and carbon dioxide gas.

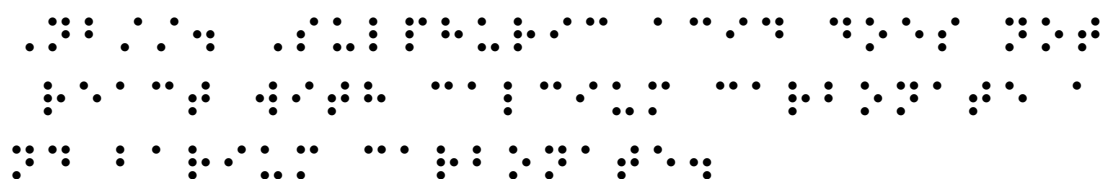


Acid + carbonate $\rightarrow$ salt + water + carbon dioxide





NB//. Sulphuric acid does not react with calcium carbonate and barium carbonate.



3. Reaction with hydrogen carbonates.



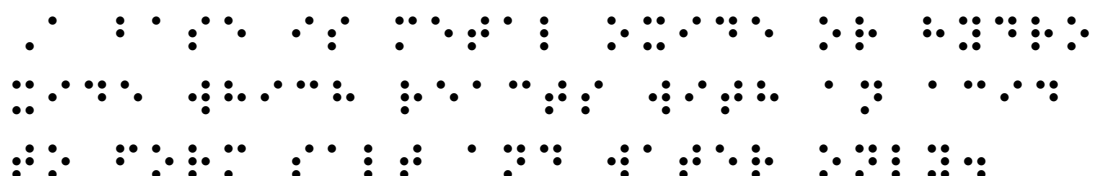
4. Reaction with bases.



Bases



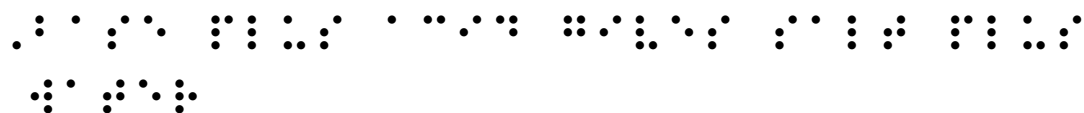
A base is metal oxide or hydroxide which reacts with an acid to form salt and water only.



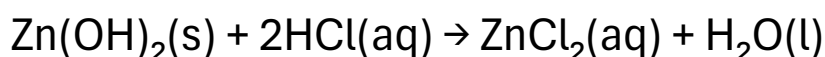
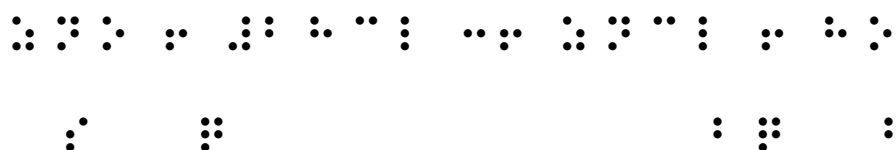
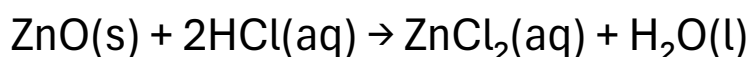
The reaction is called neutralization reaction.

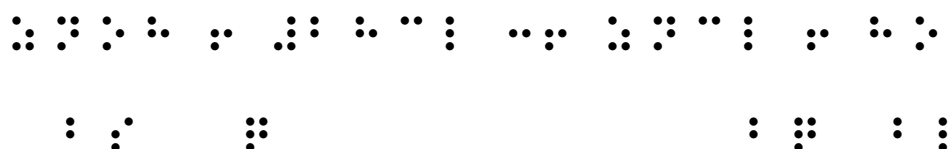


Base + acid → salt + water

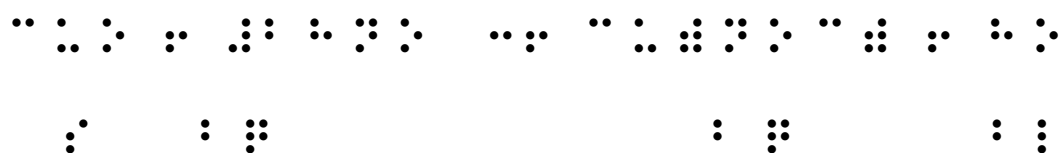
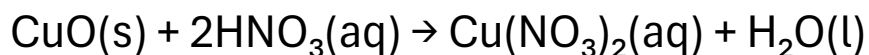


1)

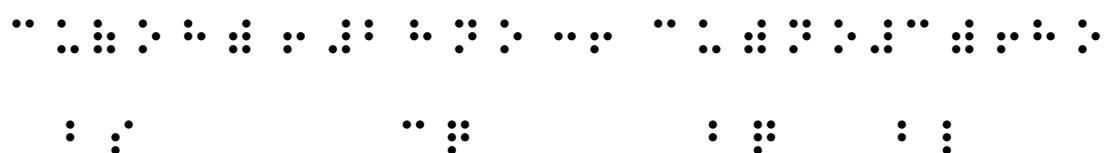
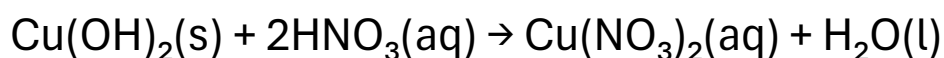




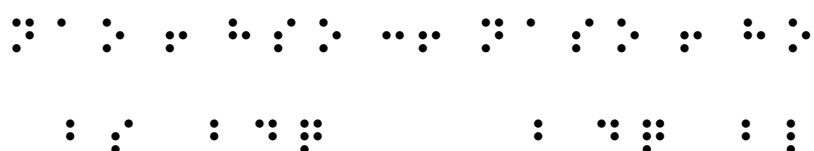
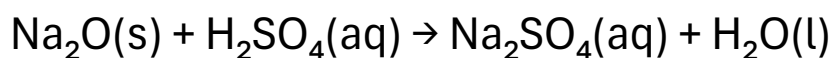
3)



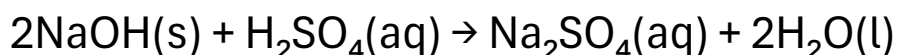
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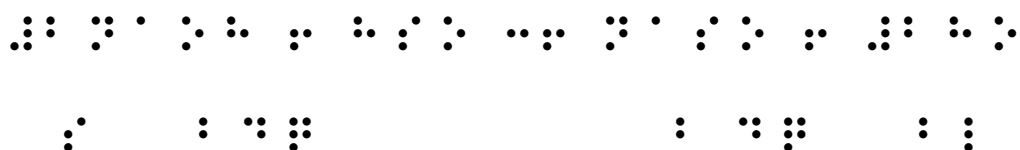


5)

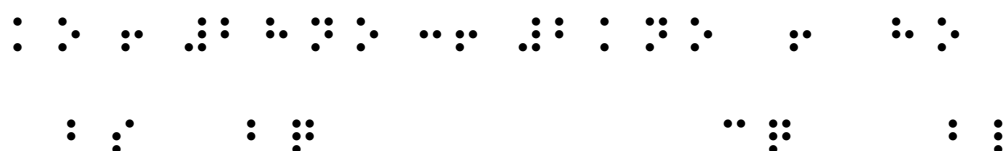
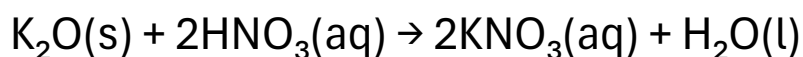


6)





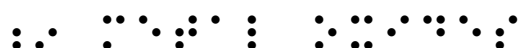
7)



There are two types of bases;



- Metal oxides



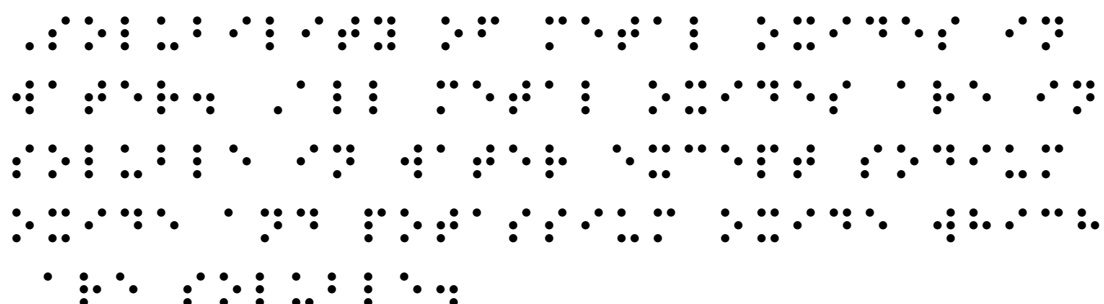
- Metal hydroxides



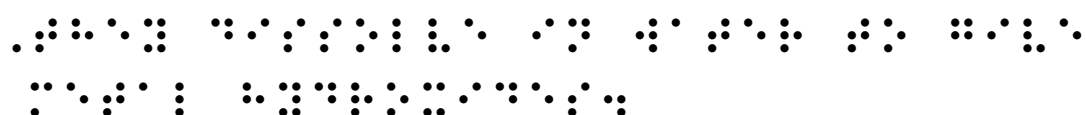
Metal oxides



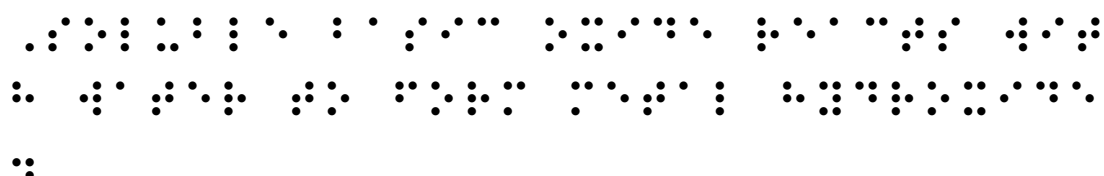
Solubility of metal oxides in water. All metal oxides are insoluble in water except sodium oxide and potassium oxide which are soluble.



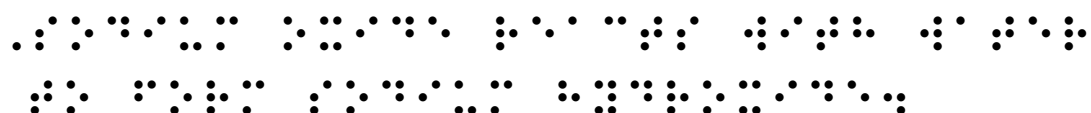
They dissolve in water to give metal hydroxides.



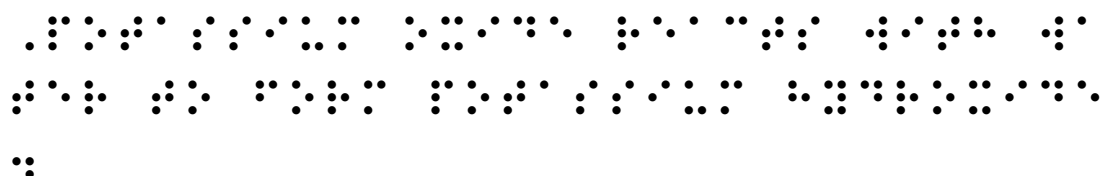
Soluble basic oxide reacts with water to form metal hydroxide.



Sodium oxide reacts with water to form sodium hydroxide.



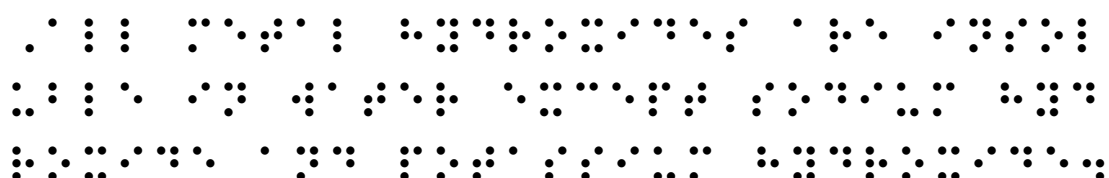
Potassium oxide reacts with water to form potassium hydroxide.



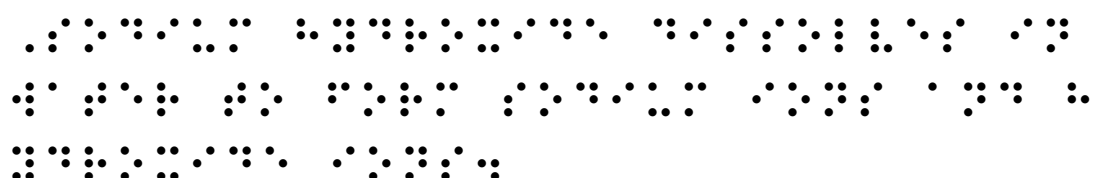
Metal hydroxides



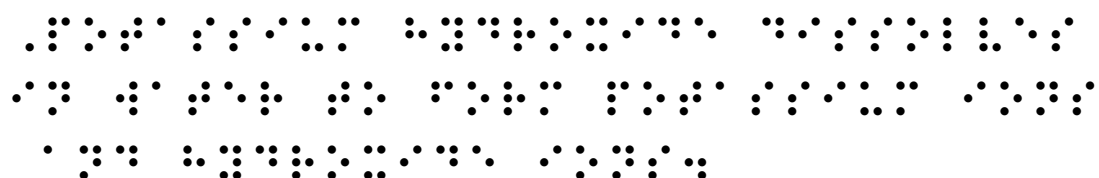
All metal hydroxides are insoluble in water except sodium hydroxide and potassium hydroxide.



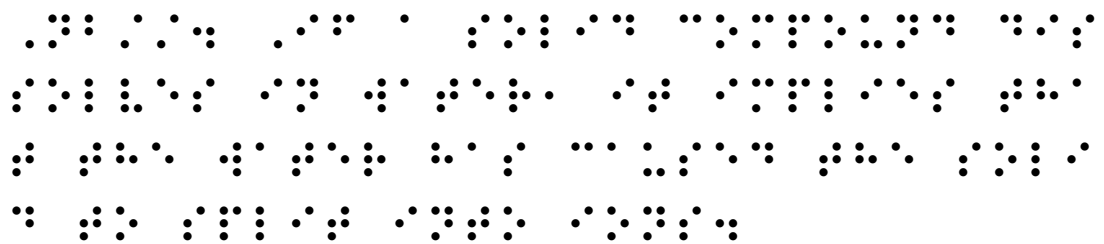
Sodium hydroxide dissolves in water to form sodium ions and hydroxide ions.



Potassium hydroxide dissolves in water to form potassium ions and hydroxide ions.



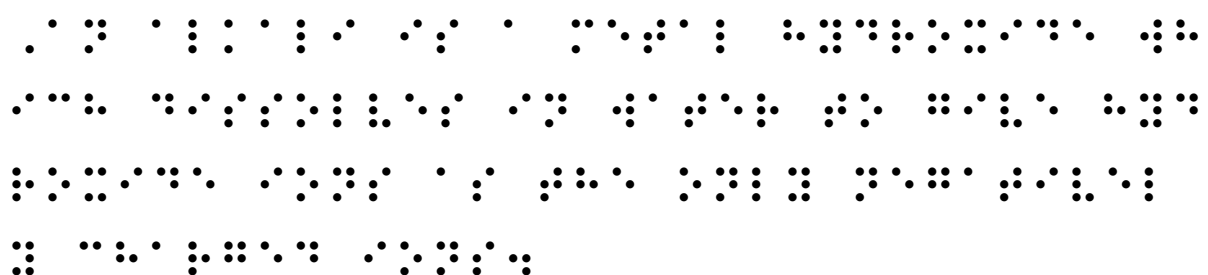
NB//. If a solid compound dissolves in water, it implies that the water has caused the solid to split into ions.



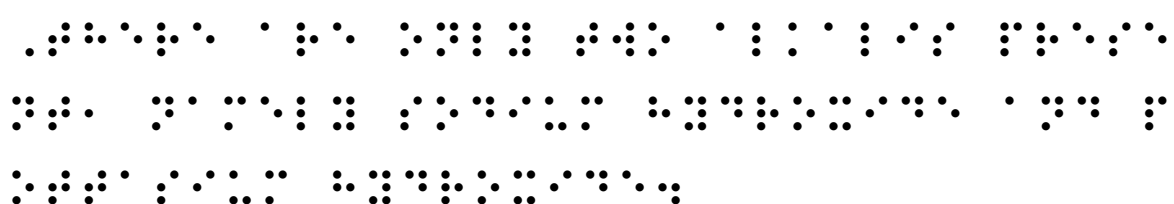
Alkalis



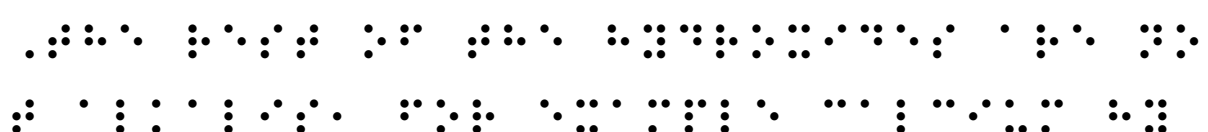
An alkali is a metal hydroxide which dissolves in water to give hydroxide ions as the only negatively charged ions.



There are only two alkalis present, namely sodium hydroxide and potassium hydroxide.



The rest of the hydroxides are not alkalis, for example calcium hydroxide, magnesium hydroxide, and copper (II) hydroxide.



Properties of bases (alkalis)

Properties of bases (alkalis)

Their solutions feel soapy or greasy.

Their solutions feel soapy or greasy.

Their solutions are bitter.

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Their solutions turn red litmus paper blue.

Their solutions turn red litmus paper blue.

They react with acids to form salt and water, and this reaction is called a neutralization reaction.

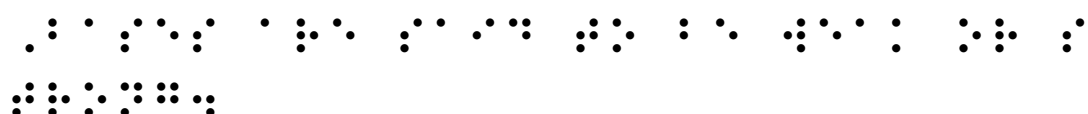
They react with acids to form salt and water, and this reaction is called a neutralization reaction.

Strength of a base

Strength of a base

Strength of a base

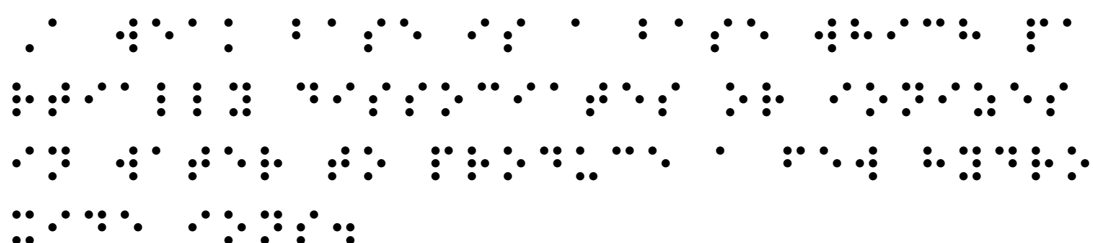
Bases are said to be weak or strong.



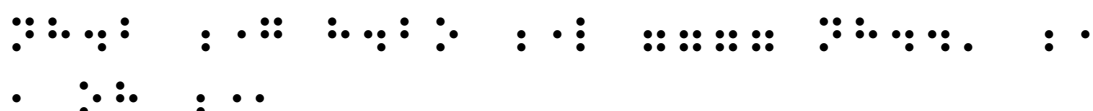
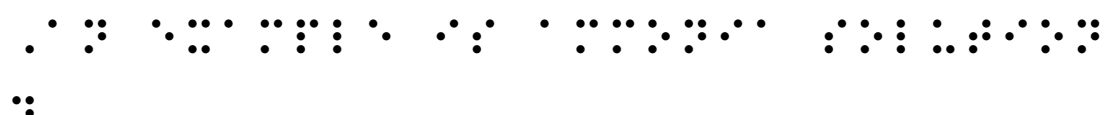
Weak Base



A weak base is a base which partially dissociates or ionizes in water to produce a few hydroxide ions.



An example is ammonia solution.



Strong base

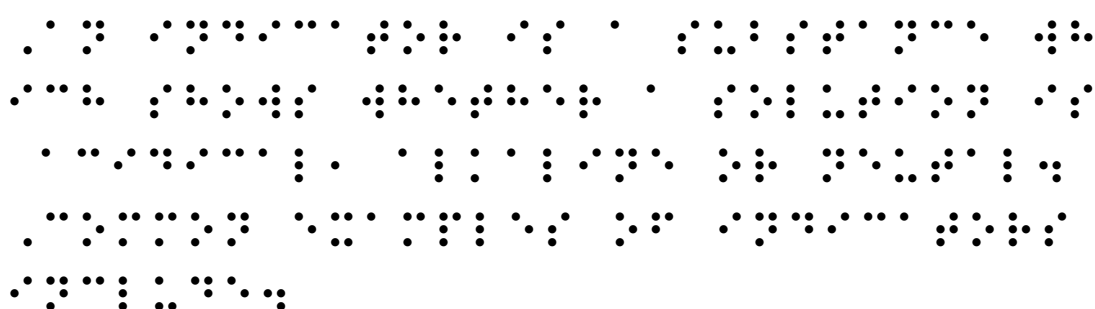


A strong base is a base which completely dissociates or ionizes in solution to produce many hydroxide ions. Examples include sodium hydroxide and potassium hydroxide.

Indicators



An indicator is a substance which shows whether a solution is acidic, alkaline, or neutral. Common examples of indicators include:



| Indicator | Colour in Acid | Colour in Base |
|---------------------|----------------|----------------|
| Methyl orange | Red | Yellow |
| Phenolphthalein | Colourless | Pink |
| Methyl red | Red | Yellow |
| Litmus paper | Red | Blue |
| Bromothymol red | Red | Blue |
| Litmus solution | Red | Blue |
| Universal indicator | Red | Blue |



Indicators are substances that change colour in the presence of acids or bases. They are used to determine the pH of a solution. The colour change is usually from red to blue for acids and from blue to red for bases. Indicators are used in titrations to determine the concentration of an acid or base.

It is important for a learner to study indicators in chemistry because indicators help identify whether a substance is acidic, alkaline, or neutral.

Indicators are used in chemistry to determine the pH of a solution. They are used in titrations to determine the concentration of an acid or base. Indicators are used in chemistry to determine the pH of a solution. They are used in titrations to determine the concentration of an acid or base.

Indicators change colour in the presence of acids or bases, making them useful for detecting chemical properties that cannot be seen directly.

Indicators are used in chemistry to determine the pH of a solution. They are used in titrations to determine the concentration of an acid or base. Indicators are used in chemistry to determine the pH of a solution. They are used in titrations to determine the concentration of an acid or base.

Indicators are substances that change color when they react with acids or bases. They are used to determine the end point of a titration.

Learning about indicators helps learners understand acid–base reactions and how substances behave when mixed together.

Indicators are important in laboratory experiments because they help determine the end point of neutralisation reactions during titration.

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The study of indicators enables learners to choose the correct indicator for a particular reaction, improving accuracy in experiments.

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Indicators are also useful in everyday life, such as testing soil acidity, water quality, and substances used in homes.

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and industries.

Indicators are substances that change colour in response to a change in the pH of a solution. They are used to determine the endpoint of a titration, which is the point at which the reaction between the analyte and the titrant is complete. Indicators are also used in a variety of other applications, such as in the detection of leaks in industrial processes and in the monitoring of environmental pollution.

Preparation of indicators in the laboratory from flowers of red cabbage

Red cabbage is a common source of natural indicators. The pigments in the leaves of red cabbage, called anthocyanins, change colour depending on the pH of the solution they are in. In acidic solutions, the pigments are red, while in basic solutions, they are blue or green. This makes red cabbage a useful source of natural indicators for a variety of applications.

In the laboratory, indicators can be obtained from plant extracts, especially brightly coloured flowers such as hibiscus.

Hibiscus flowers are a common source of natural indicators. The pigments in the petals of hibiscus flowers, called anthocyanins, change colour depending on the pH of the solution they are in. In acidic solutions, the pigments are red, while in basic solutions, they are blue or green. This makes hibiscus a useful source of natural indicators for a variety of applications.

Procedure:

1. Collect some brightly coloured flowers (e.g. hibiscus or red cabbage), crush the flowers thoroughly into a paste using a mortar, and add ethanol to the paste.

The quick brown fox jumps over the lazy dog

2. Stir the solution well, then filter the solution into a boiling tube. The filtrate obtained is the indicator; discard the residue.

3. Record the colour of the filtrate. (Which type of indicator is this?)






NB//. Ethanol is used as a solvent because indicators are insoluble in water but soluble in ethanol, which is a non-polar solvent. Therefore, the indicator obtained can be used to test for the acidity and alkalinity of different solutions.

. . . : : . . . : : . . . : : . . . : : . . . : :
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Universal indicator is a mixture of indicators in solution. It enables us to classify solutions into neutral, alkaline, and acidic.

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pH refers to the degree of alkalinity or acidity of a solution. This is shown by a pH meter.

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A pH meter classifies solutions as alkaline, acidic, or neutral. In a pH meter, the scale ranges from 0–14.

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Acidic solutions have pH less than 7.

[illegible]

Alkaline solutions have pH greater than 7.

[illegible]

Neutral solutions have pH of 7.

[illegible]

Describe how indicators help learners identify substances and determine the end point in chemical reactions.

[illegible]

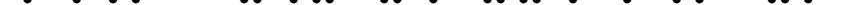
During a practical lesson, a learner is asked to determine whether an unknown solution is acidic, alkaline, or neutral.

[illegible]

The solution is colourless and has no smell, making it difficult to identify its nature by observation alone.

[illegible]

The learner adds a few drops of an indicator to the solution.



Immediately, the colour of the solution changes.

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840.

From the colour observed, the learner is able to tell whether the solution is acidic, alkaline, or neutral.

[illegible]

In another experiment, the learner carries out a titration between an acid and a base.

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840.

As the base is added slowly to the acid, nothing seems to happen at first.

[illegible]

When the exact amount needed for neutralisation is reached, the indicator suddenly changes colour.

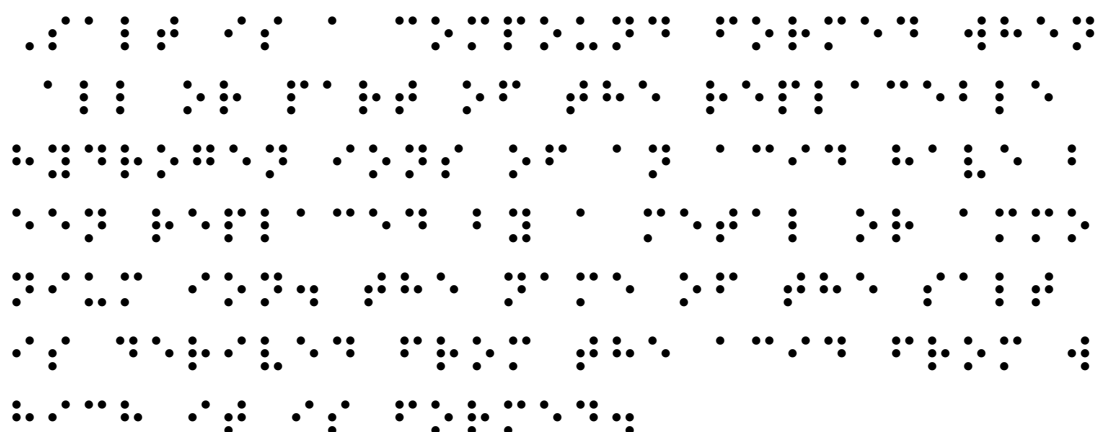
This colour change shows that neutralisation has occurred.

From these activities, the learner understands that indicators are essential for identifying substances and determining the end point of reactions.

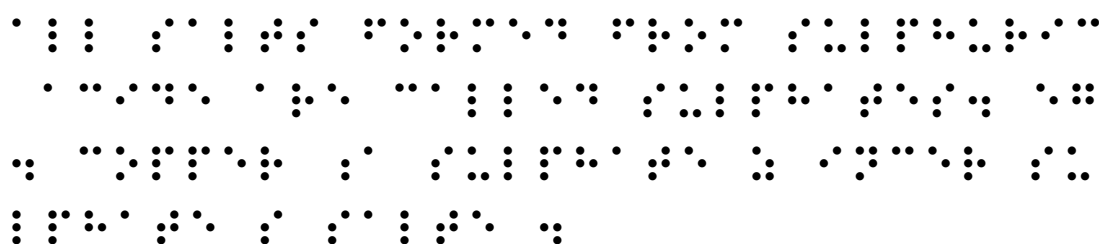
Salt



A salt is a compound formed when all or part of the replaceable hydrogen ions of an acid have been replaced by a metal or ammonium ion. The name of the salt is derived from the acid from which it is formed.



All salts formed from sulphuric acid are called sulphates, e.g., Copper (II) sulphate, Zinc sulphate, Sodium sulphate, Barium sulphate, Iron (II) sulphate, Iron (III) sulphate, Ammonium sulphate, Aluminium sulphate.



All salts derived from hydrochloric acid are called chlorides, e.g., Sodium chloride, Magnesium chloride, Zinc chloride, Iron (III) chloride.

Salts are ionic compounds formed from the reaction of an acid and a base. They are composed of cations and anions. Salts are found in many natural and synthetic materials. They are used in various industries and in everyday life. Salts are also important in biological systems.

All salts derived from nitric acid are called nitrates, e.g., Aluminium nitrate, Copper (II) nitrate, Sodium nitrate, Ammonium nitrate, Calcium nitrate.

Salts are ionic compounds formed from the reaction of an acid and a base. They are composed of cations and anions. Salts are found in many natural and synthetic materials. They are used in various industries and in everyday life. Salts are also important in biological systems.

Learning salts is important in chemistry because salts are among the most common chemical substances studied at this level.

Salts are ionic compounds formed from the reaction of an acid and a base. They are composed of cations and anions. Salts are found in many natural and synthetic materials. They are used in various industries and in everyday life. Salts are also important in biological systems.

Salts are formed from the reaction between acids and bases, and understanding them helps learners master neutralisation reactions.

Salts are ionic compounds formed from the reaction of an acid and a base. They are composed of cations and anions. Salts are found in many natural and synthetic materials. They are used in various industries and in everyday life. Salts are also important in biological systems.

Knowledge of salts enables learners to correctly identify whether a compound is solid, liquid, aqueous, or gaseous when writing chemical equations.

Understanding the solubility of salts helps learners predict whether a reaction will produce a precipitate or remain in solution.

Salts are important in qualitative analysis, where they are used to identify unknown ions through colour changes, precipitates, and flame tests.

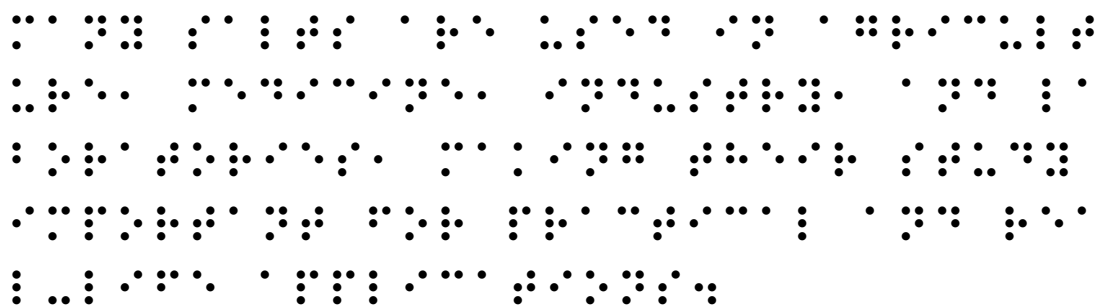
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Many salts are used in agriculture, medicine, industry, and laboratories, making their study important for practical and real-life applications.



Types of salts:



- Normal salt



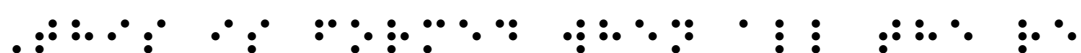
- Acid salt



Normal salt



This is formed when all the replaceable hydrogen ions of an acid have been replaced by a metal or ammonium ion.



These salts are formed by the reaction of an acid with a metal or ammonium ion. The reaction is as follows:

These salts do not contain hydrogen ions from the acid.

Examples include sodium sulphate, sodium chloride, copper (II) sulphate.

Examples include sodium sulphate, sodium chloride, copper (II) sulphate.

These salts are formed by the reaction of an acid with a metal or ammonium ion. The reaction is as follows:

Acid salt

These salts are formed by the reaction of an acid with a metal or ammonium ion. The reaction is as follows:

This is formed when only part of the replaceable hydrogen ions has been replaced by a metal or ammonium ion.

Acid salts are mainly formed by sulphuric acid because it has more than one replaceable hydrogen ion.

Acid salts are mainly formed by sulphuric acid because it has more than one replaceable hydrogen ion.

These salts are formed by the reaction of an acid with a metal or ammonium ion. The reaction is as follows:

nitric acid and hydrochloric acid cannot form acid salts.

Nitric acid and hydrochloric acid cannot form acid salts.

Examples include sodium hydrogen sulphate, ammonium hydrogen sulphate, sodium hydrogen carbonate.

Examples include sodium hydrogen sulphate, ammonium hydrogen sulphate, sodium hydrogen carbonate.

Examples include sodium hydrogen sulphate, ammonium hydrogen sulphate, sodium hydrogen carbonate.

Methods of preparing salts in the laboratory

The method used depends on the solubility of the salt in water. Generally:

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The method used depends on the solubility of the salt in water. Generally:

- All sulphates are soluble in cold water except barium sulphate, lead (II) sulphate, and calcium sulphate.

The method used depends on the solubility of the salt in water. Generally:

The solubility of a salt helps to determine whether a compound is solid, liquid, aqueous or gas in a chemical reaction.

Knowing the solubility of a salt helps to determine whether a compound is solid, liquid, aqueous or gas in a chemical reaction.

Solubility rules also help learners predict whether a precipitate will form during a chemical reaction.

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Preparation methods:

There are two main methods for preparing salts:

1. Crystallization

This method is used to prepare soluble salts.

2. Precipitation (double decomposition)

This method is used to prepare insoluble salts.

Crystallization

This method is used to prepare soluble salts.

This method is used to prepare soluble salts. During this method, salt crystals are formed from a salt solution.

The following procedures are used during the process of crystallization:

The following procedures are used during the process of crystallization:

There are two main methods for preparing salts:

A salt solution is made by dissolving a metal oxide or a metal in an acid until no more dissolves.

There are two main methods for preparing salts:

undissolved solids are then filtered out to obtain a filtrate which contains the salt solution.

The undissolved solids are then filtered out to obtain a filtrate which contains the salt solution.

The filtrate is then put in an evaporating dish and heated to drive off the excess water from the salt solution.

The filtrate is then put in an evaporating dish and heated to drive off the excess water from the salt solution.

The hot solution is removed from the source of heat and allowed to cool in order for the crystals to form.

The hot solution is removed from the source of heat and allowed to cool in order for the crystals to form.

The liquid that remains on top of the crystals after cooling is called mother liquor.

The liquid that remains on top of the crystals after cooling is called mother liquor.

The crystals formed are then filtered out from the mother liquor, dried on filter paper to obtain the salt.

The crystals formed are then filtered out from the mother liquor, dried on filter paper to obtain the salt.

When the acid is added to the metal oxide, a reaction takes place. The acid is neutralized and the metal salt is formed. The reaction is exothermic, meaning it releases heat. The metal salt is then crystallized by evaporating the water. The crystals are then dried and weighed.

NB//. To ensure that all the acid put in the beaker is reacted completely, the metal oxide or metal must be added until no more dissolves. This implies that all the acid put in the beaker is reacted.

The reaction is carried out in a beaker. The acid is added to the beaker and the metal oxide is added until no more dissolves. The reaction is exothermic, meaning it releases heat. The metal salt is then crystallized by evaporating the water. The crystals are then dried and weighed.

Preparation of zinc (II) sulphate crystals

The reaction is carried out in a beaker. The acid is added to the beaker and the metal oxide is added until no more dissolves. The reaction is exothermic, meaning it releases heat. The metal salt is then crystallized by evaporating the water. The crystals are then dried and weighed.

Dilute sulphuric acid is put in a beaker and warmed.

The reaction is carried out in a beaker. The acid is added to the beaker and the metal oxide is added until no more dissolves. The reaction is exothermic, meaning it releases heat. The metal salt is then crystallized by evaporating the water. The crystals are then dried and weighed.

Zinc granules or zinc oxide is added to the warm acid little at a time with constant stirring until no more can dissolve.

The reaction is carried out in a beaker. The acid is added to the beaker and the metal oxide is added until no more dissolves. The reaction is exothermic, meaning it releases heat. The metal salt is then crystallized by evaporating the water. The crystals are then dried and weighed.

The undissolved zinc or zinc oxide is filtered out, and a colourless filtrate is obtained.

The undissolved zinc or zinc oxide is filtered out, and a colourless filtrate is obtained.

The filtrate is then transferred into an evaporating dish and heated to evaporate excess water from the solution.

The filtrate is then transferred into an evaporating dish and heated to evaporate excess water from the solution.

The hot solution is removed from the heat source and allowed to cool for the crystals of zinc sulphate to form.

The hot solution is removed from the heat source and allowed to cool for the crystals of zinc sulphate to form.

The crystals are then filtered out and dried between the filter papers.

The crystals are then filtered out and dried between the filter papers.

The acid is warmed to increase the rate of reaction.

Preparation of iron (II) sulphate from iron and dilute sulphuric acid

[illegible]

Dilute sulphuric acid is put in a beaker and warmed.

Figure 1. The proposed system architecture. The input image is processed by a feature extractor to produce a feature vector. This vector is then passed through a classification module to determine the final output class.

Iron fillings are added to the warm acid little at a time with constant stirring until no more can dissolve. This ensures that all the acid has reacted.

.

The undissolved iron filings are filtered out and the green filtrate obtained contains iron (II) sulphate.

۱. در صورتی که در یک سال گذشته، شما هیچ‌یک از موارد زیر را تجربه نکرده‌اید، به مرحله بعدی بروید.
 ۲. اگر در یک سال گذشته، شما هر یک از موارد زیر را تجربه کرده‌اید، به مرحله بعدی بروید.
 ۳. اگر در یک سال گذشته، شما هر یک از موارد زیر را تجربه کرده‌اید، به مرحله بعدی بروید.
 ۴. اگر در یک سال گذشته، شما هر یک از موارد زیر را تجربه کرده‌اید، به مرحله بعدی بروید.

The filtrate is then transferred into an evaporating dish and heated to evaporate excess water from the solution.

$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ is then added to the filtrate and the solution is heated to evaporate excess water from the solution.

The hot solution is removed from the heat source and allowed to cool for the crystals of iron sulphate to be formed.

$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ is then added to the filtrate and the solution is heated to evaporate excess water from the solution.

The crystals are then filtered out and dried between the filter papers.

$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ is then added to the filtrate and the solution is heated to evaporate excess water from the solution.

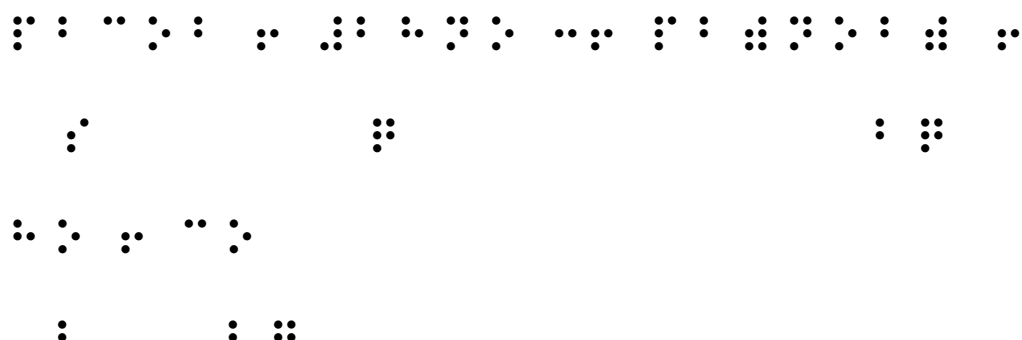
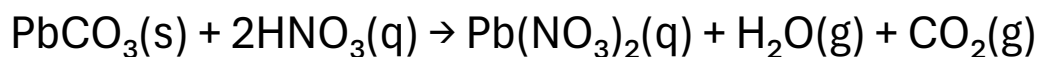
NB//. The acid is warmed to increase the rate of reaction.

$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ is then added to the filtrate and the solution is heated to evaporate excess water from the solution.

Preparation of lead (II) nitrate crystals from lead (II) carbonate and dilute nitric acid

$\text{PbCO}_3 + 2\text{HNO}_3 \rightarrow \text{Pb(NO}_3)_2 + \text{H}_2\text{O} + \text{CO}_2$

Lead(II) carbonate reacts with dilute nitric acid to form lead(II) nitrate, water, and carbon dioxide gas.



- Dilute nitric acid is put in a beaker and warmed.

The acid is warmed in a beaker over a Bunsen burner. The acid is then poured into a test tube and the test tube is held in a test tube holder.

- Lead (II) carbonate crystals are added to the warm acid little at a time with constant stirring using a glass rod until no more can dissolve. During this reaction, carbon dioxide gas is evolved. This means that all the acid has reacted.

The lead(II) carbonate crystals are added to the warm acid in a beaker. The crystals are added little at a time with constant stirring using a glass rod until no more can dissolve. During this reaction, carbon dioxide gas is evolved. This means that all the acid has reacted.

- The undissolved lead (II) carbonate is filtered out to obtain a colourless filtrate which contains lead (II) nitrate.

Lead (II) carbonate is filtered out to obtain a colourless filtrate which contains lead (II) nitrate. The filtrate is then transferred into an evaporating dish and heated to evaporate excess water from the solution until crystals begin to form.

- The filtrate is then transferred into an evaporating dish and heated to evaporate excess water from the solution until crystals begin to form.

The filtrate is then transferred into an evaporating dish and heated to evaporate excess water from the solution until crystals begin to form. The hot solution is removed from the heat source and allowed to cool for more crystals of lead (II) nitrate to be formed.

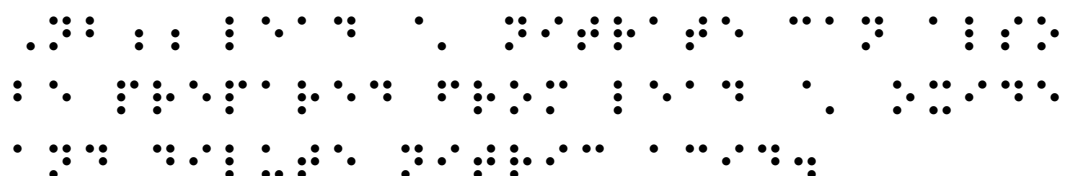
- The hot solution is removed from the heat source and allowed to cool for more crystals of lead (II) nitrate to be formed.

The hot solution is removed from the heat source and allowed to cool for more crystals of lead (II) nitrate to be formed. The crystals are then filtered out and dried between the filter papers.

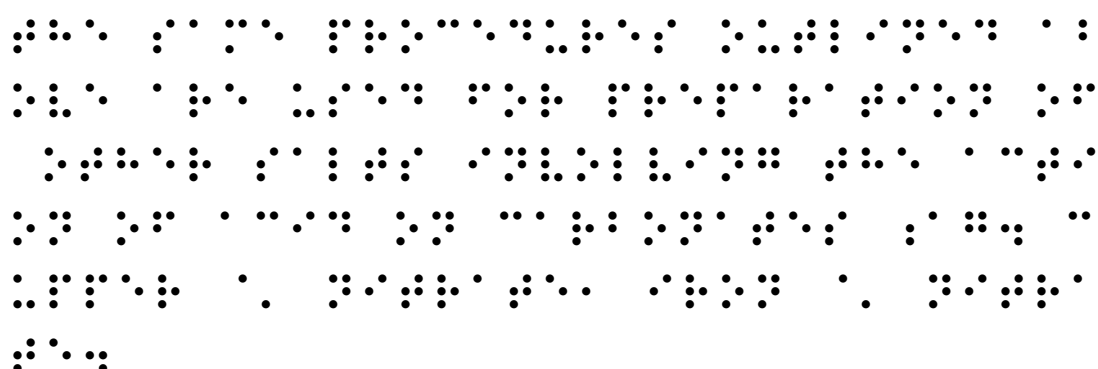
- The crystals are then filtered out and dried between the filter papers.

The crystals are then filtered out and dried between the filter papers. The crystals are then filtered out and dried between the filter papers.

NB//. Lead (II) nitrate can also be prepared from lead (II) oxide and dilute nitric acid.



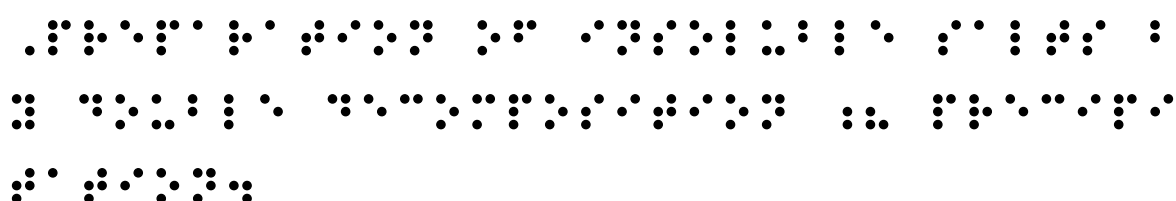
The same procedures outlined above are used for preparation of other salts involving the action of acid on carbonates (e.g., copper (II) nitrate, iron (II) nitrate).



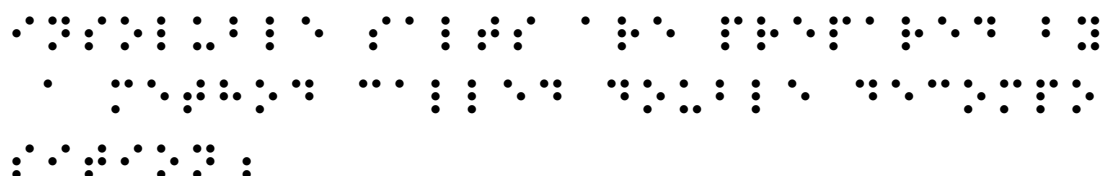
Double decomposition (precipitation)



Preparation of insoluble salts by double decomposition (precipitation)



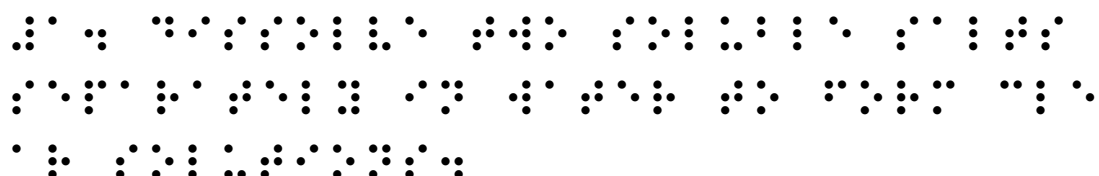
Insoluble salts are prepared by a method called double decomposition/precipitation method. During the process, two soluble salts are mixed and an insoluble salt is formed or precipitated.



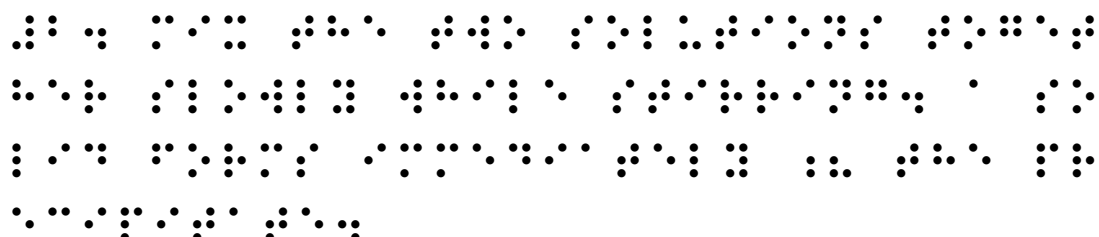
Procedure:



1. Dissolve two soluble salts separately in water to form clear solutions.



2. Mix the two solutions together slowly while stirring. A solid forms immediately — this is the precipitate.



3. Filter the mixture using filter paper to separate the solid precipitate from the remaining solution (called the filtrate).

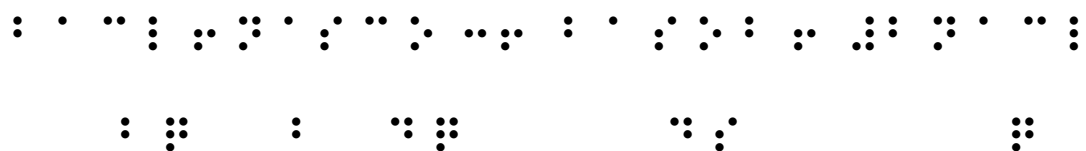
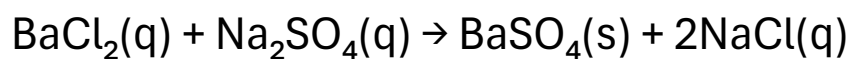
4. Wash the precipitate with a small amount of cold water to remove any soluble impurities.

5. Dry the precipitate between filter papers to obtain the pure insoluble salt.

5. Dry the precipitate between filter papers to obtain the pure insoluble salt.

Mixing aqueous solutions of barium chloride and sodium sulphate gives a white precipitate of barium sulphate:

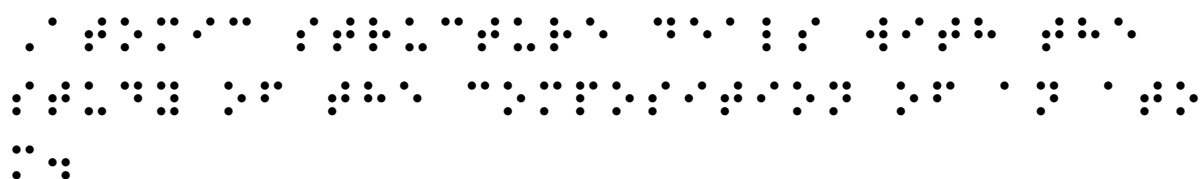
159 | Page



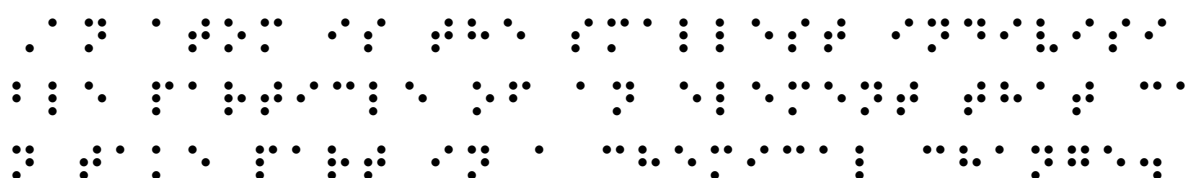
ATOMIC STRUCTURE



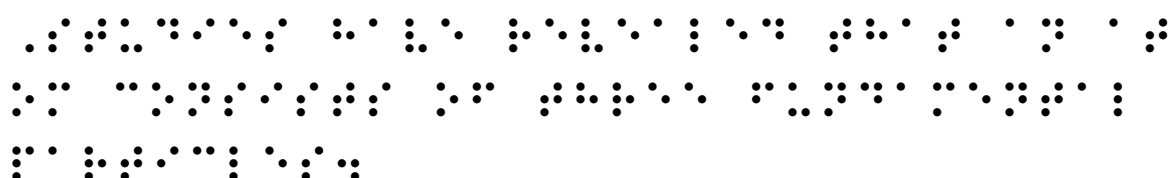
Atomic structure deals with the study of the composition of an atom.



An atom is the smallest indivisible particle of an element that can take part in a chemical change.



Studies have revealed that an atom consists of three fundamental particles.



They include;



- Protons



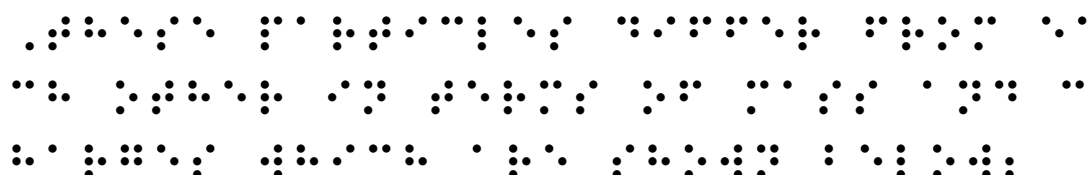
- Neutrons



- Electrons



These particles differ from each other in terms of charges which are shown below;

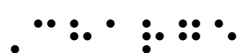


Particle

Charge



Proton



+



Neutron



No charge .



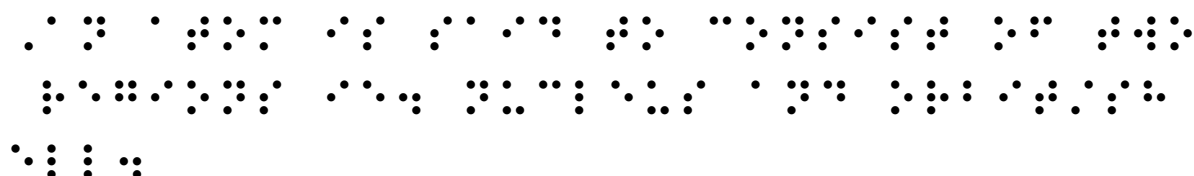
Electron



-



An atom is said to consist of two regions i.e. nucleus and orbit/shell.



Characteristics of the nucleus

• The nucleus is the central part of the atom.

- It contains the protons and neutrons which are collectively called nucleons.

• The nucleus is made up of protons and neutrons. Protons are positively charged particles and neutrons are neutral particles. The nucleus is very small in size compared to the atom.

- It occupies the central part of the atom. This part is smaller compared to the orbit.

• The nucleus is extremely dense (heavy) because of the presence of protons and neutrons.

- The mass of the atom (atomic mass/mass number) is the sum of the number of protons and neutrons in the nucleus of the atom.

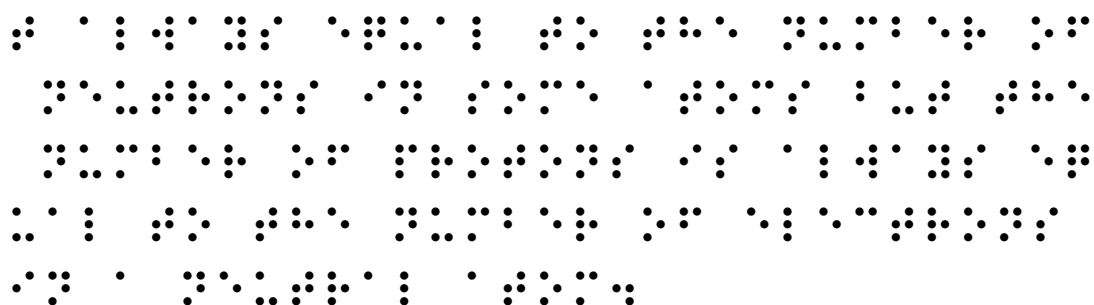
• The number of protons is not always equal to the number of neutrons in some atoms but the number of protons is always equal to the number of electrons in a neutral atom.

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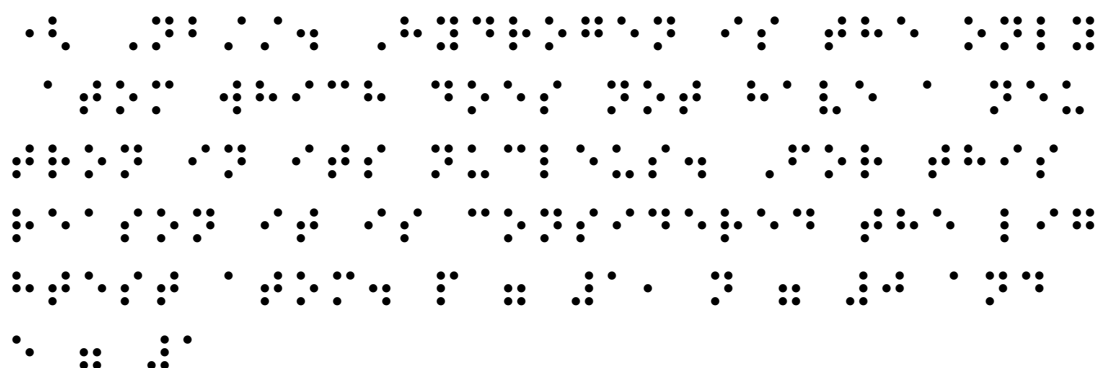
• The number of protons is not always equal to the number of neutrons in some atoms but the number of protons is always equal to the number of electrons in a neutral atom.



- In sodium, $p = 11$, $n = 12$ and $e = 11$.



- NB: Hydrogen is the only atom which does not have a neutron in its nucleus. For this reason it is considered the lightest atom. $p = 1$, $n = 0$ and $e = 1$.



Atomic number (Z) and atomic mass (A)

Atomic number (Z) is the number of protons in the nucleus of an atom. Atomic mass (A) is the sum of the number of protons and neutrons in the nucleus of an atom.

An atom of any element differs from those of the other elements due to the difference brought about by atomic number and atomic mass of different elements.

Atomic number (Z) is the number of protons in the nucleus of an atom. Atomic mass (A) is the sum of the number of protons and neutrons in the nucleus of an atom. The atomic number (Z) and atomic mass (A) are used to identify an element and its isotopes.

Atomic number

Atomic number (Z) is the number of protons in the nucleus of an atom.

This is defined as the number of protons in the nucleus of an atom and is indicated by letter Z.

The atomic number (Z) is the number of protons in the nucleus of an atom. It is denoted by the letter Z. The atomic mass (A) is the sum of the number of protons and neutrons in the nucleus of an atom. It is denoted by the letter A.

Atomic mass (mass number)

Atomic mass (A) is the sum of the number of protons and neutrons in the nucleus of an atom.

It refers to the total number of protons and neutrons in the nucleus of an atom. It is denoted by letter A.

The atomic mass (A) is the sum of the number of protons and neutrons in the nucleus of an atom. It is denoted by the letter A.

Therefore, an atom of an element can be represented in terms of its atomic number and mass number.

Example notation:

Where A = mass number

Summary

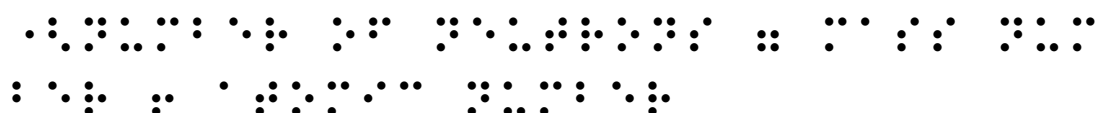
- Atomic number = number of protons

- Mass number = number of protons + number of neutrons

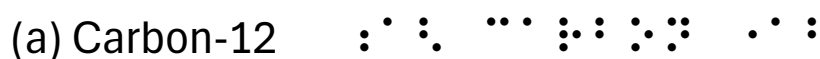
- Atomic number = number of protons



- Number of neutrons = mass number – atomic number



EXAMPLES



$\cdot \cdot \cdot \leftarrow$ superscript 12 (half-size)

- • ← main element C

:^{..} ← subscript 6 (half-size)

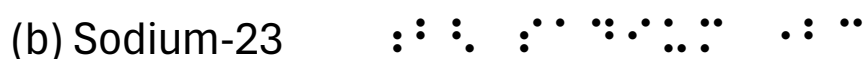
- Number of protons = 6



- Number of electrons = 6



- Number of neutrons = $12 - 6 = 6$



- Number of electrons = 1



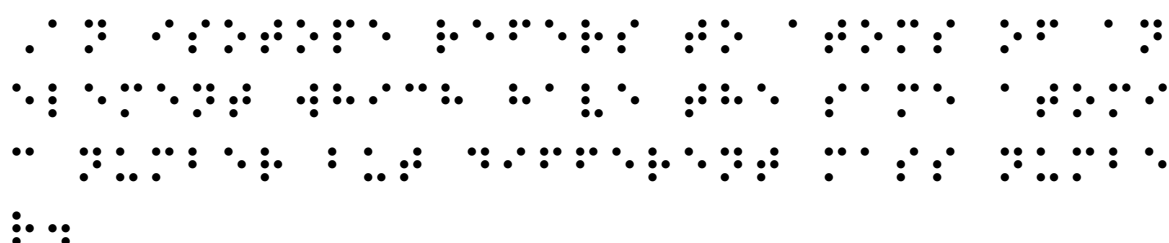
- Number of neutrons = 0



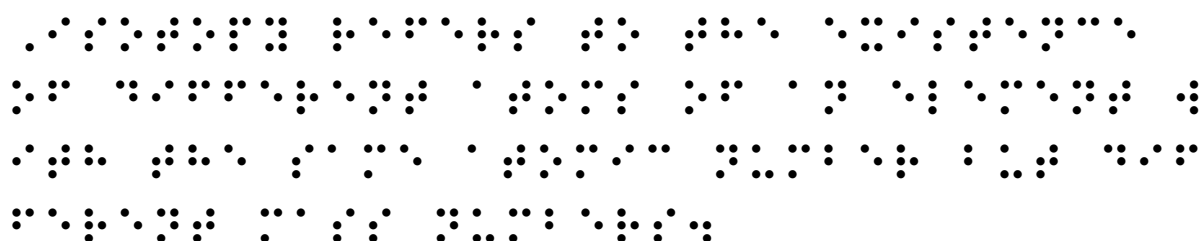
Isotopes and Isotopy



An isotope refers to atoms of an element which have the same atomic number but different mass number.

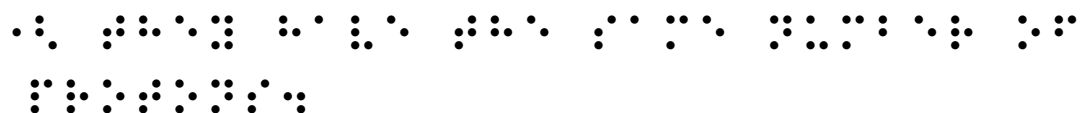


Isotopy refers to the existence of different atoms of an element with the same atomic number but different mass numbers.



Characteristics of isotopes

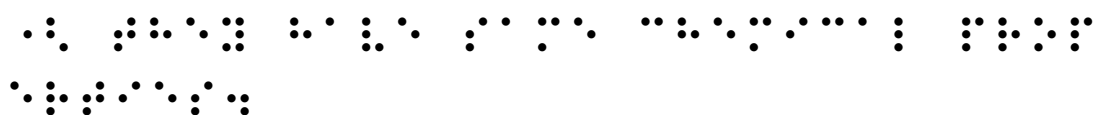
• They have the same number of protons.



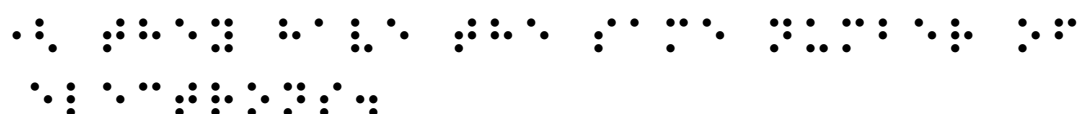
- They have different number of neutrons.



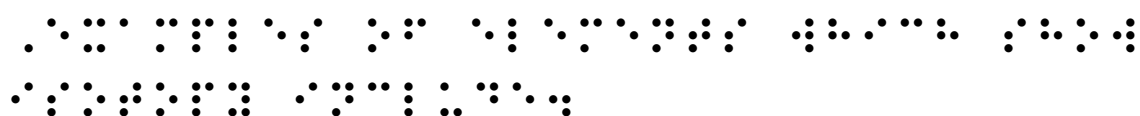
- They have same chemical properties.



- They have the same number of electrons.



Examples of elements which show isotopy include:



Chlorine $\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot$

$\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot$ $\leftarrow$ Cl-35

$\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot$ $\leftarrow$ Cl-36

$\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot$ $\leftarrow$ Cl-37

Hydrogen $\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot$

$\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot$ $\leftarrow$ H-1

$\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot$ $\leftarrow$ H-2

$\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot$ $\leftarrow$ H-3

Oxygen $\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot$

$\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot$ $\leftarrow$ O-16

$\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot$ $\leftarrow$ O-18

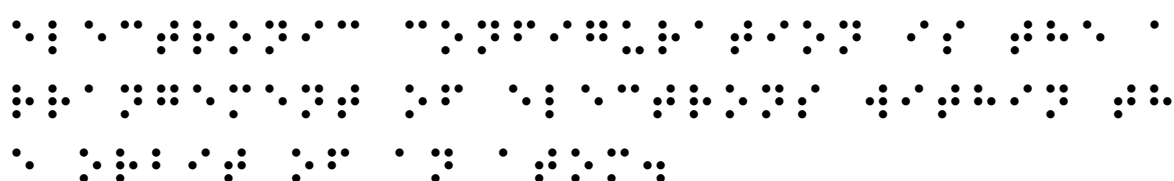
Lead

$\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot$ $\leftarrow$ Pb-206

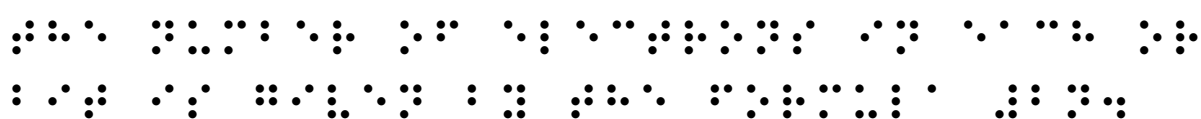
Electronic Configuration and Structure



Electronic configuration is the arrangement of electrons within the orbit of an atom.



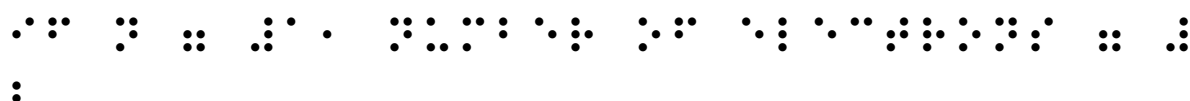
The number of electrons in each orbit is given by the formula $2n^2$, where n is the number of orbits.



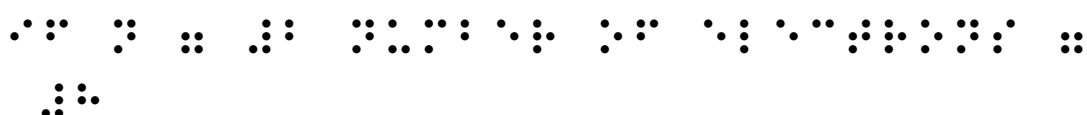
$n = 1, 2, 3 \dots$



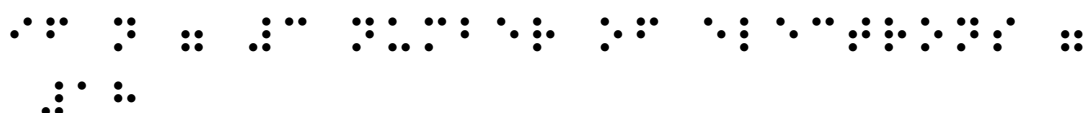
If $n = 1$, number of electrons = 2.



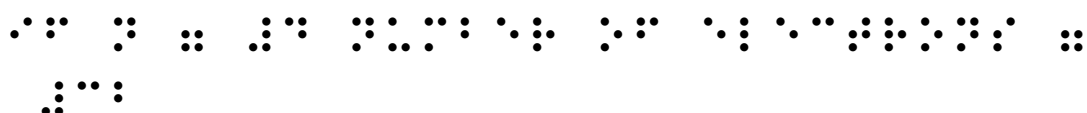
If $n = 2$, number of electrons = 8.



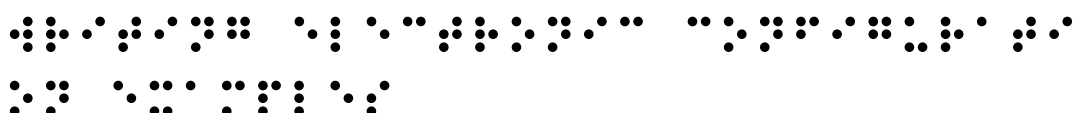
If $n = 3$, number of electrons = 18.



If $n = 4$, number of electrons = 32.



Writing Electronic Configuration Examples



1. Hydrogen (1) $\rightarrow$ 1



2. Chlorine (17) $\rightarrow$ 2:8:7



3. Sodium (11) $\rightarrow$ 2:8:1



4. Magnesium (12) $\rightarrow$ 2:8:2



5. Phosphorus (15) $\rightarrow$ 2:8:5



6. Potassium (19) $\rightarrow 2:8:8:1$



7. Calcium (20) $\rightarrow$ 2:8:8:2



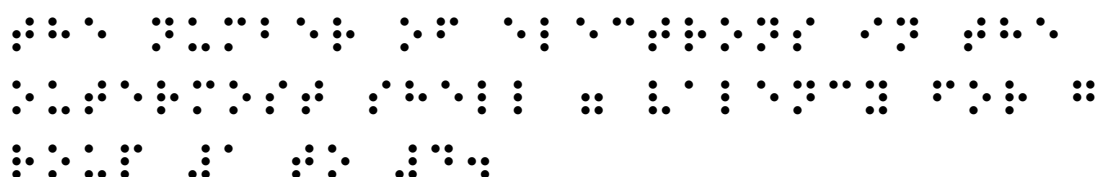
8. Chlorine (17, 35.5) $\rightarrow$ 2:8:7



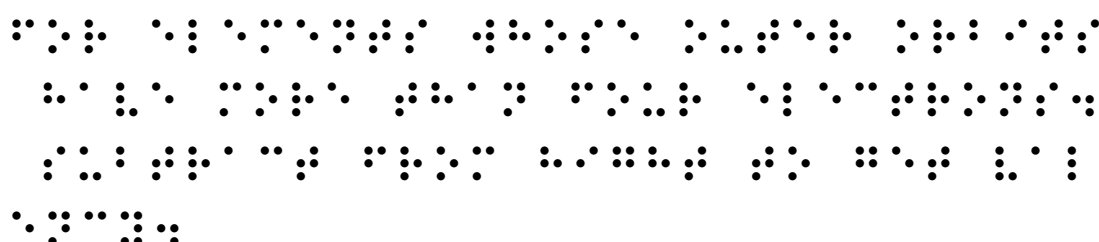
Note



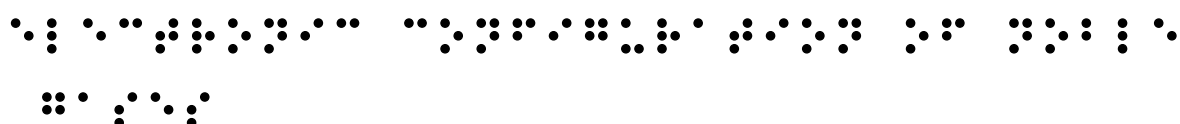
The number of electrons in the outermost shell = valency
for elements from group 1 to group 4.



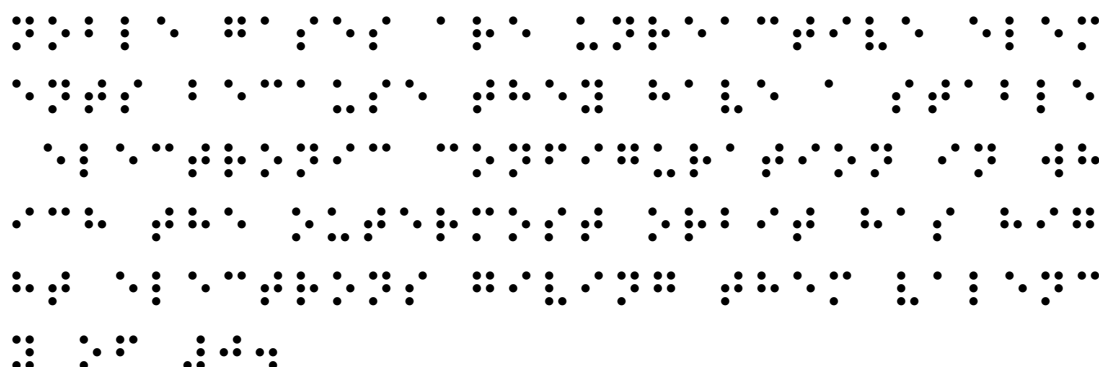
For elements whose outer orbits have more than four electrons, subtract from eight to get valency.

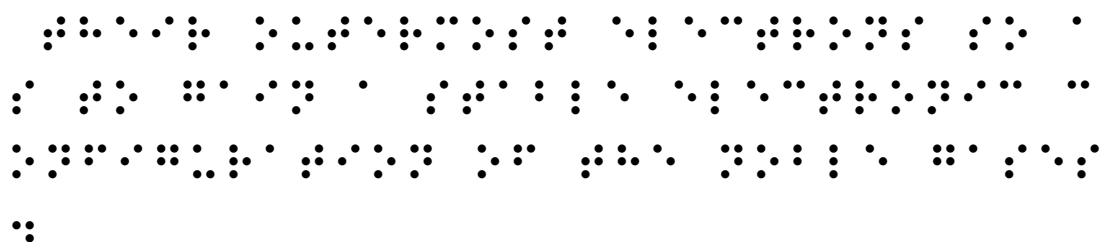


Electronic Configuration of Noble Gases

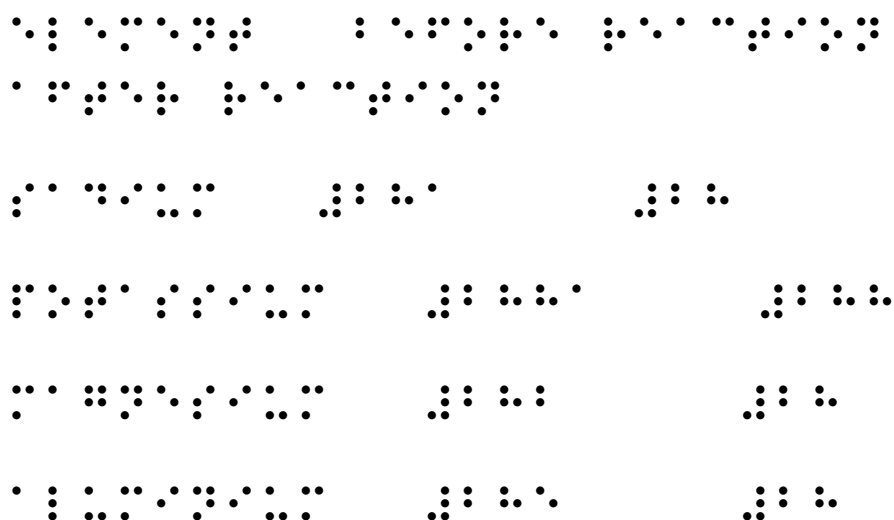


Noble gases are unreactive elements because they have a stable electronic configuration in which their outermost orbit has 8 electrons giving them valency of 0.

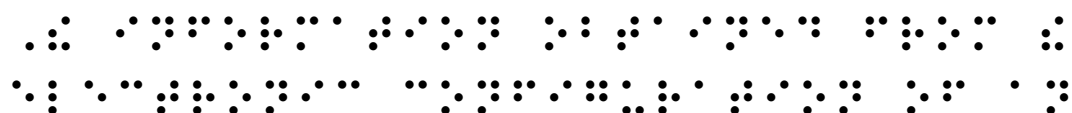




| Element | Before Reaction | After Reaction |
|-----------|-----------------|----------------|
| Sodium | 2:8:1 | 2:8 |
| Potassium | 2:8:8:1 | 2:8:8 |
| Magnesium | 2:8:2 | 2:8 |
| Aluminium | 2:8:3 | 2:8 |



The information obtained from the electronic configuration of an atom can be used in the following ways.

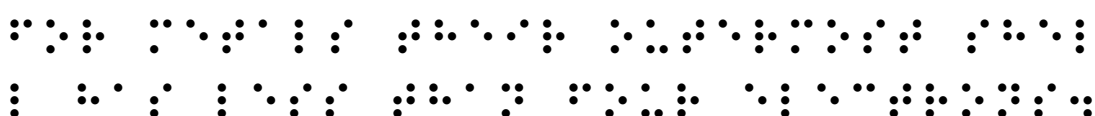




To tell whether the element is a metal or non metal.



For metals their outermost shell has less than four electrons.



Mg, 2:8:2



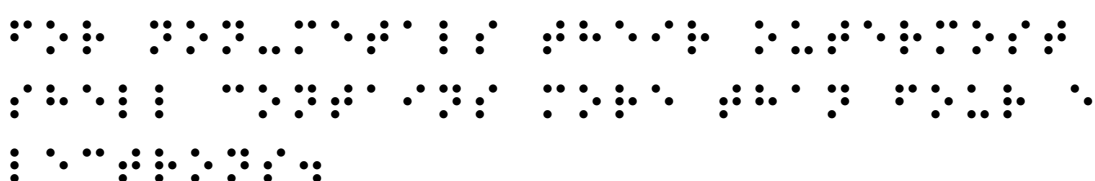
Na, 2:8:1



Al, 2:8:3



For non-metals their outermost shell contains more than four electrons.



O, 2:6



N, 2:5



Scenario : Understanding Electronic Configuration in Reactivity

Li: 1s² 2s¹ Na: 1s² 2s² 2p⁶ 3s¹ K: 1s² 2s² 2p⁶ 3s² 3p⁶ 4s¹

A learner is asked to predict which element will react fastest with water: lithium, sodium, or potassium.

Li: 1s² 2s¹ Na: 1s² 2s² 2p⁶ 3s¹ K: 1s² 2s² 2p⁶ 3s² 3p⁶ 4s¹

The learner recalls the electronic configurations of the three elements.

Li: 1s² 2s¹ Na: 1s² 2s² 2p⁶ 3s¹ K: 1s² 2s² 2p⁶ 3s² 3p⁶ 4s¹

He understands that potassium has one electron in its outermost shell, making it very reactive.

Li: 1s² 2s¹ Na: 1s² 2s² 2p⁶ 3s¹ K: 1s² 2s² 2p⁶ 3s² 3p⁶ 4s¹

The learner predicts that lithium will react slowly, sodium faster, and potassium fastest.

Li: 1s² 2s¹ Na: 1s² 2s² 2p⁶ 3s¹ K: 1s² 2s² 2p⁶ 3s² 3p⁶ 4s¹

Through this activity, the learner sees how electronic configuration explains the reactivity of elements.

1s² 2s² 2p⁶ 3s² 3p⁶ 4s² 3d¹⁰ 4p⁶ 5s² 4d¹⁰ 5p⁶ 6s² 4f¹⁴ 5d¹⁰ 6p⁶ 7s² 5f¹⁴ 6d¹⁰ 7p⁶ 8s² 6f¹⁴ 7d¹⁰ 8p⁶ 9s² 7f¹⁴ 8d¹⁰ 9p⁶ 10s² 8f¹⁴ 9d¹⁰ 10p⁶ 11s² 9f¹⁴ 10d¹⁰ 11p⁶ 12s² 10f¹⁴ 11d¹⁰ 12p⁶ 13s² 11f¹⁴ 12d¹⁰ 13p⁶ 14s² 12f¹⁴ 13d¹⁰ 14p⁶ 15s² 13f¹⁴ 14d¹⁰ 15p⁶ 16s² 14f¹⁴ 15d¹⁰ 16p⁶ 17s² 15f¹⁴ 16d¹⁰ 17p⁶ 18s² 16f¹⁴ 17d¹⁰ 18p⁶ 19s² 17f¹⁴ 18d¹⁰ 19p⁶ 20s² 18f¹⁴ 19d¹⁰ 20p⁶ 21s² 19f¹⁴ 20d¹⁰ 21p⁶ 22s² 20f¹⁴ 21d¹⁰ 22p⁶ 23s² 21f¹⁴ 22d¹⁰ 23p⁶ 24s² 22f¹⁴ 23d¹⁰ 24p⁶ 25s² 23f¹⁴ 24d¹⁰ 25p⁶ 26s² 24f¹⁴ 25d¹⁰ 26p⁶ 27s² 25f¹⁴ 26d¹⁰ 27p⁶ 28s² 26f¹⁴ 27d¹⁰ 28p⁶ 29s² 27f¹⁴ 28d¹⁰ 29p⁶ 30s² 28f¹⁴ 29d¹⁰ 30p⁶ 31s² 29f¹⁴ 30d¹⁰ 31p⁶ 32s² 30f¹⁴ 31d¹⁰ 32p⁶ 33s² 31f¹⁴ 32d¹⁰ 33p⁶ 34s² 32f¹⁴ 33d¹⁰ 34p⁶ 35s² 33f¹⁴ 34d¹⁰ 35p⁶ 36s² 34f¹⁴ 35d¹⁰ 36p⁶ 37s² 35f¹⁴ 36d¹⁰ 37p⁶ 38s² 36f¹⁴ 37d¹⁰ 38p⁶ 39s² 37f¹⁴ 38d¹⁰ 39p⁶ 40s² 38f¹⁴ 39d¹⁰ 40p⁶ 41s² 39f¹⁴ 40d¹⁰ 41p⁶ 42s² 40f¹⁴ 41d¹⁰ 42p⁶ 43s² 41f¹⁴ 42d¹⁰ 43p⁶ 44s² 42f¹⁴ 43d¹⁰ 44p⁶ 45s² 43f¹⁴ 44d¹⁰ 45p⁶ 46s² 44f¹⁴ 45d¹⁰ 46p⁶ 47s² 45f¹⁴ 46d¹⁰ 47p⁶ 48s² 46f¹⁴ 47d¹⁰ 48p⁶ 49s² 47f¹⁴ 48d¹⁰ 49p⁶ 50s² 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250s² 248f¹⁴ 249d¹⁰ 250p⁶ 251s² 249f¹⁴ 250d¹⁰ 251p⁶ 252s² 250f¹⁴ 251d¹⁰ 252p⁶ 253s² 251f¹⁴ 252d¹⁰ 253p⁶ 254s² 252f¹⁴ 253d¹⁰ 254p⁶ 255s² 253f¹⁴ 254d¹⁰ 255p⁶ 256s² 254f¹⁴ 255d¹⁰ 256p⁶ 257

BONDING AND STRUCTURE

Chemical bonding is the process of forming a chemical bond between two or more atoms.

Chemical Bonding

Chemical bonding is the process of forming a chemical bond between two or more atoms.

Bonding is the combination of two or more atoms during a chemical reaction to form a stable compound.

During the reaction, a chemical bond is formed between the atoms. The bond is formed by the sharing of electrons between the atoms. The bond is formed by the sharing of electrons between the atoms. The bond is formed by the sharing of electrons between the atoms.

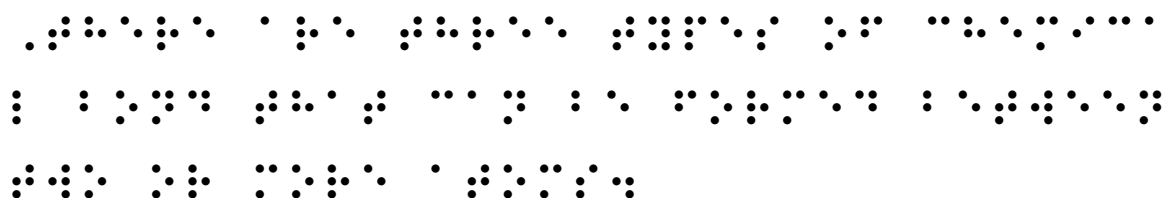
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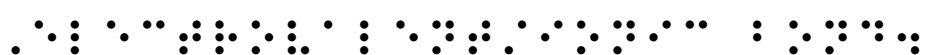
Atoms bond in order to attain a stable outermost shell, usually by having two or eight electrons.

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There are three types of chemical bond that can be formed between two or more atoms.



Electrovalent/ionic bond.



Covalent bond.



Metallic bond.



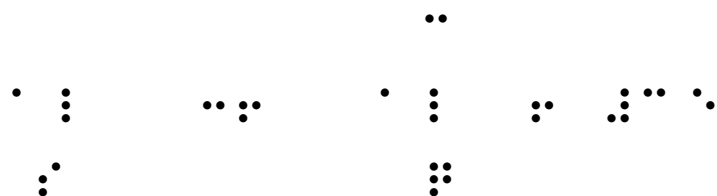
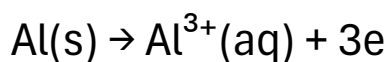
Dative bond.



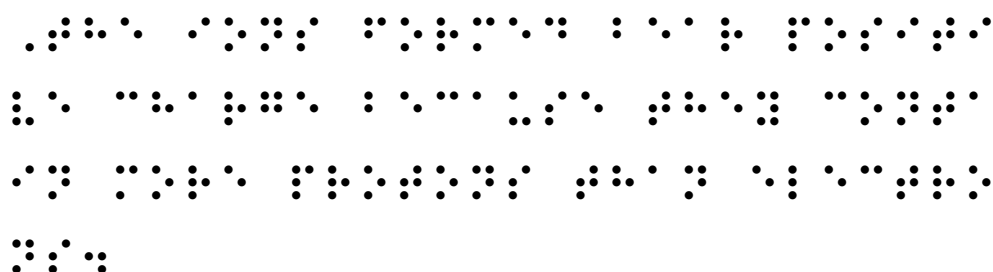
Electrovalent/Ionic bonding



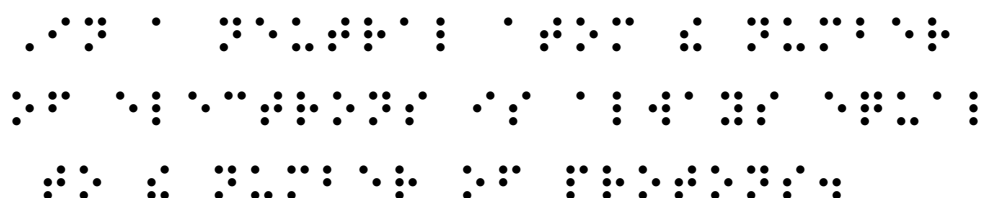
This is a type of bonding that occurs as a result of complete transfer of electrons from one atom to another.



The ions formed bear positive charge because they contain more protons than electrons.



In a neutral atom the number of electrons is always equal to the number of protons.

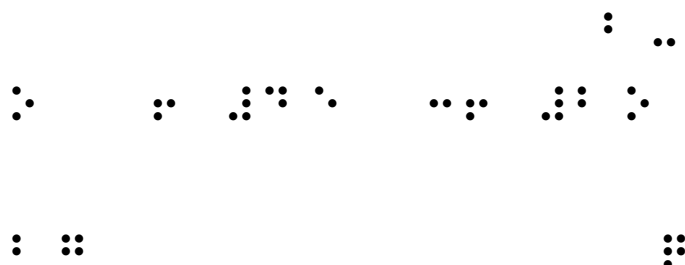
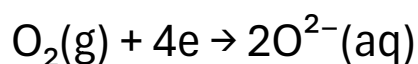


(b) Negative ions (anions).

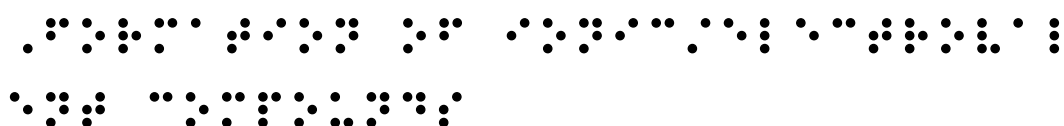


This ion is formed as a result of gain of electrons by a non-metal atom.

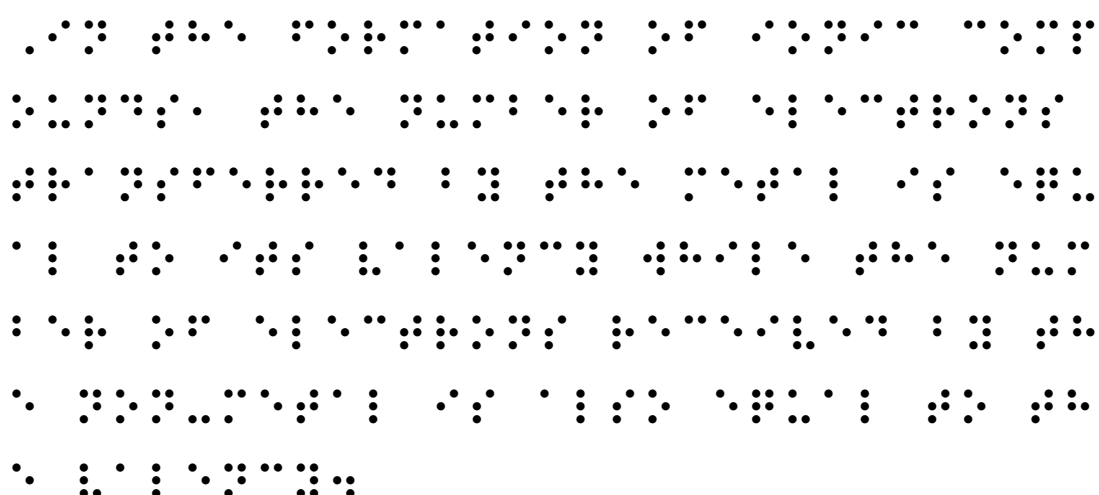




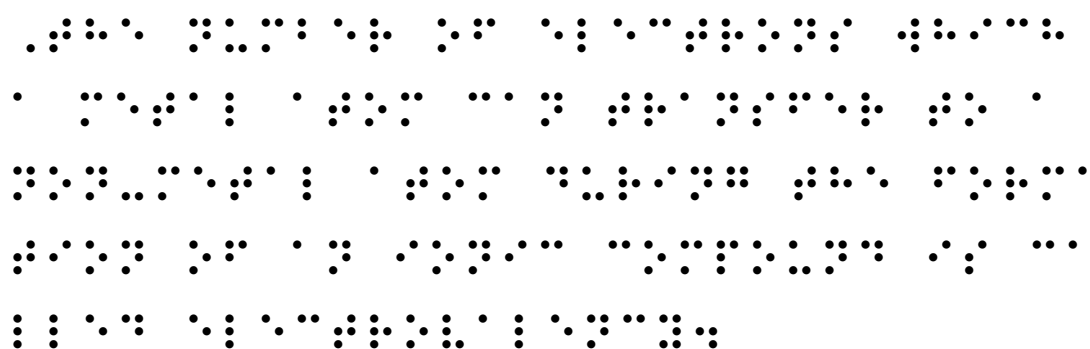
Formation of ionic/electrovalent compounds



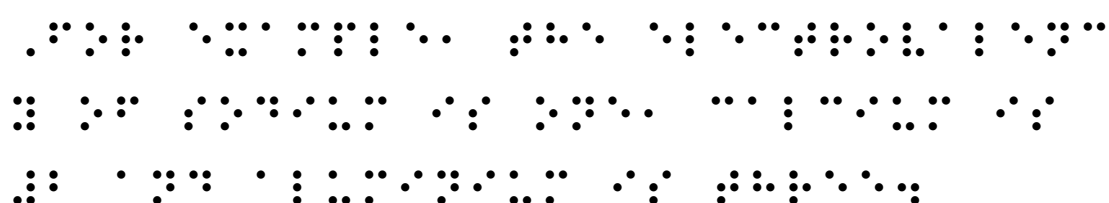
In the formation of ionic compounds, the number of electrons transferred by the metal is equal to its valency while the number of electrons received by the non-metal is also equal to the valency.



The number of electrons which a metal atom can transfer to a non-metal atom during the formation of an ionic compound is called electrovalency.

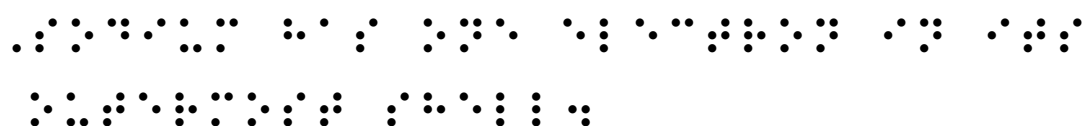


For example, the electrovalency of sodium is one, calcium is two and aluminium is three.

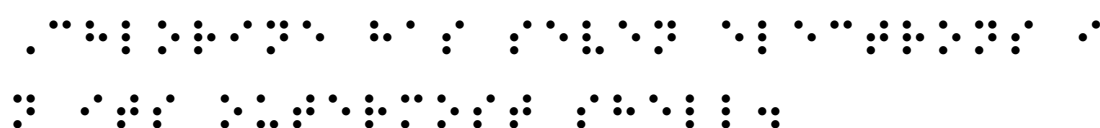


Formation of sodium chloride

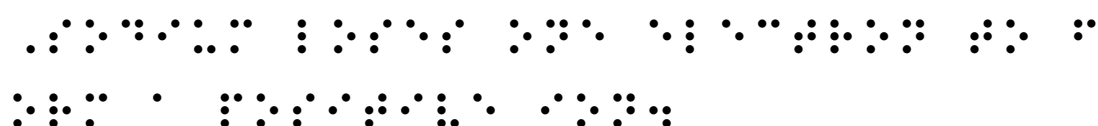
Sodium has one electron in its outermost shell.



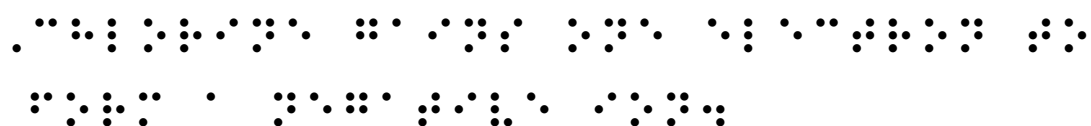
Chlorine has seven electrons in its outermost shell.



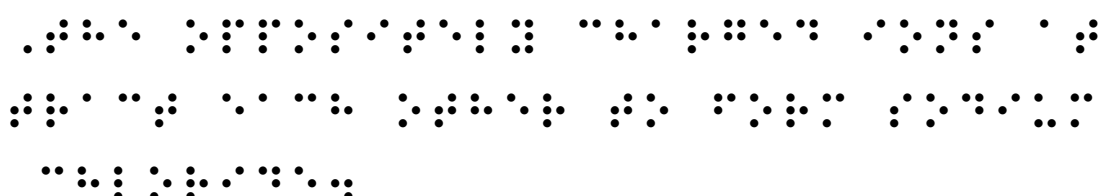
Sodium loses one electron to form a positive ion.



Chlorine gains one electron to form a negative ion.



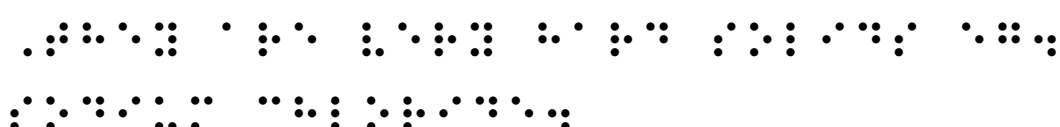
The oppositely charged ions attract each other to form sodium chloride.



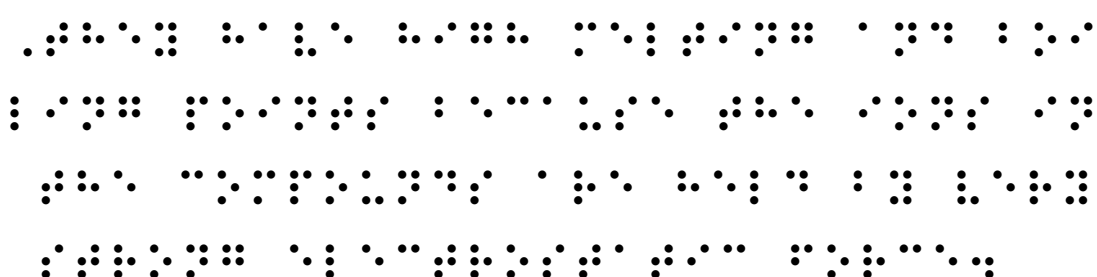
Properties of ionic compounds



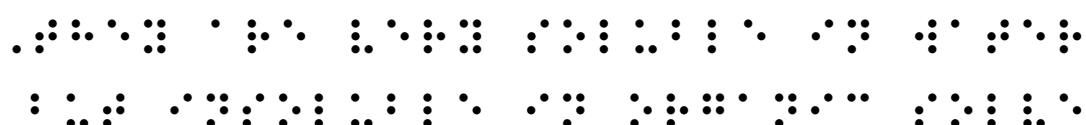
They are very hard solids e.g. sodium chloride.

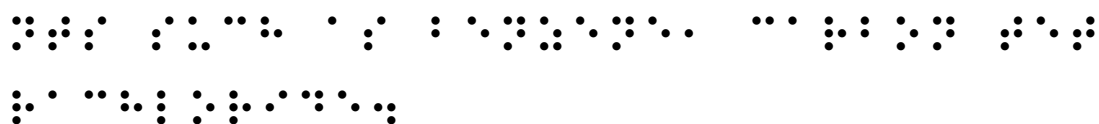


They have high melting and boiling points because the ions in the compounds are held by very strong electrostatic force.

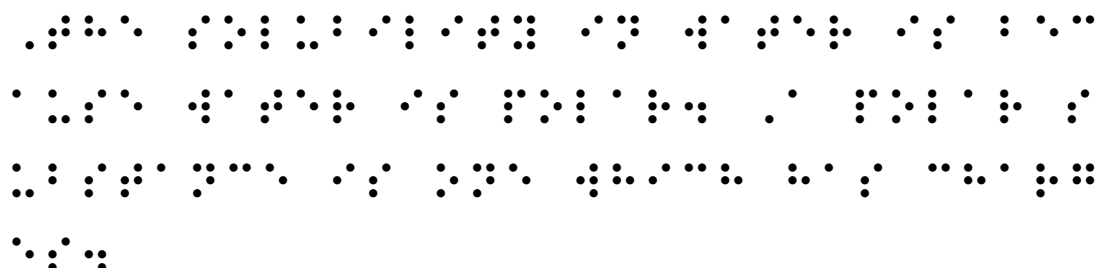


They are very soluble in water but insoluble in organic solvents such as benzene, carbon tetrachloride.

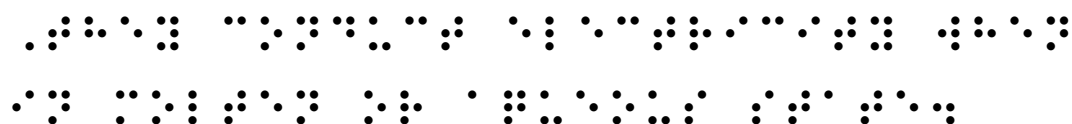




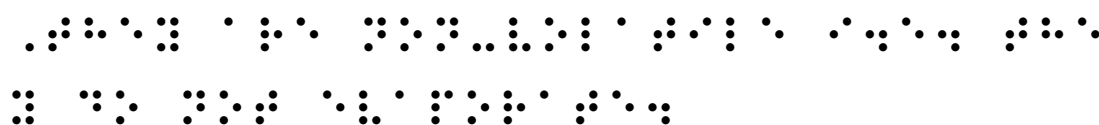
The solubility in water is because water is polar. A polar substance is one which has charges.



They conduct electricity when in molten or aqueous state.



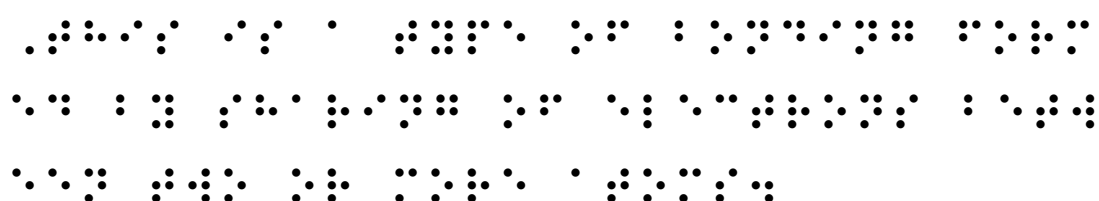
They are non-volatile i.e. they do not evaporate.



Covalent bonding

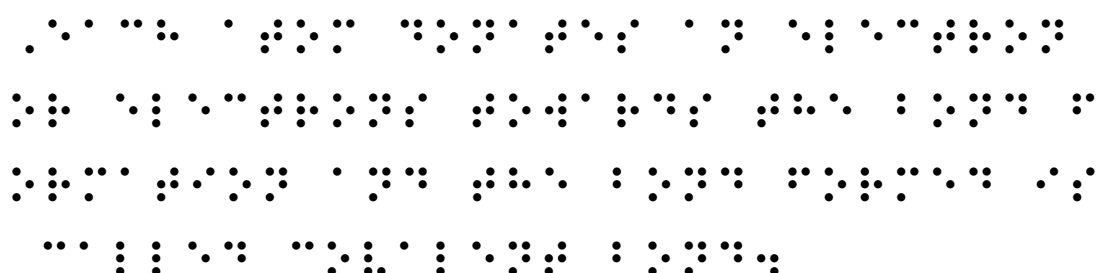


This is a type of bonding formed by sharing of electrons between two or more atoms.

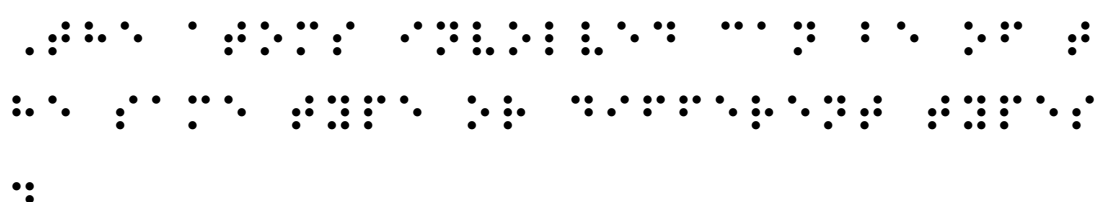


Each atom donates an electron or electrons towards the bond formation and the bond formed is called covalent

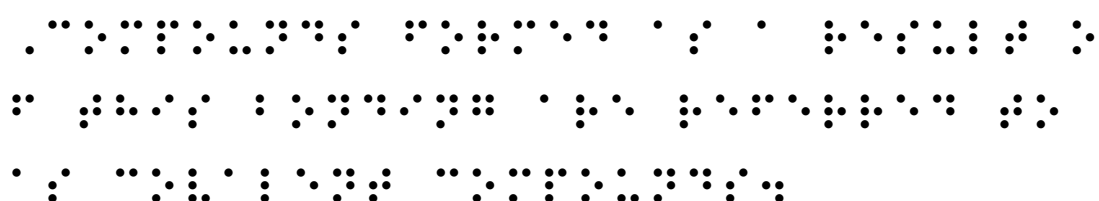
bond.



The atoms involved can be of the same type or different types.



Compounds formed as a result of this bonding are referred to as covalent compounds.



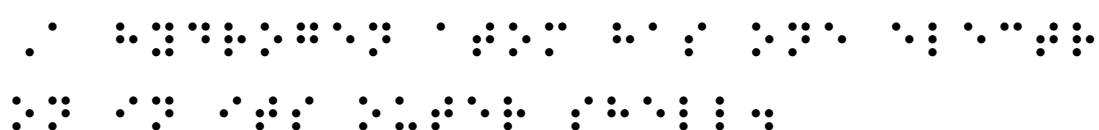
Formation of covalent compounds



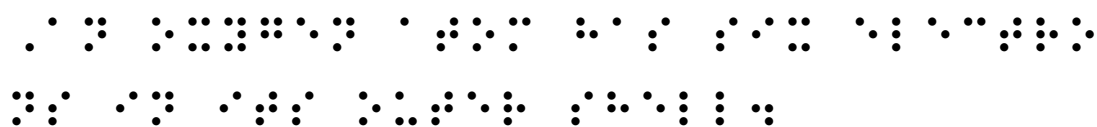
Formation of water



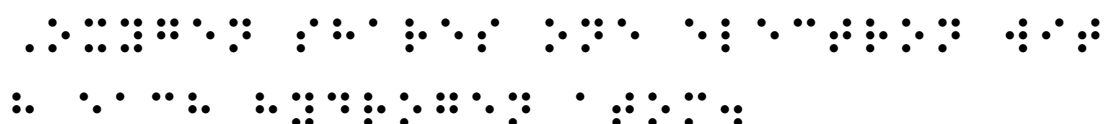
A hydrogen atom has one electron in its outer shell.



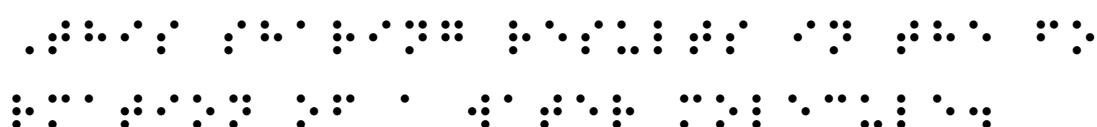
An oxygen atom has six electrons in its outer shell.



Oxygen shares one electron with each hydrogen atom.



This sharing results in the formation of a water molecule.



(a) Formation of chlorine



(b) Formation of hydrogen



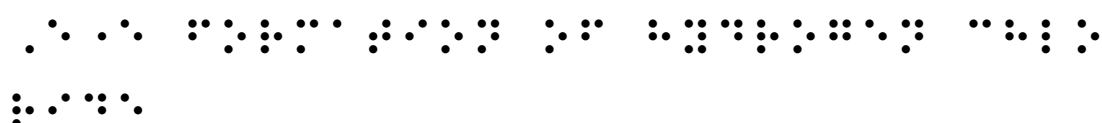
(c) Formation of oxygen



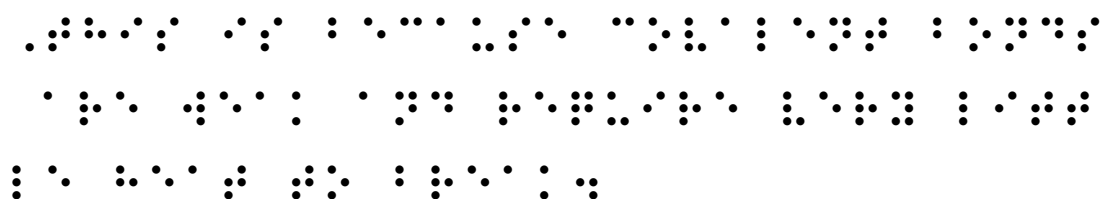
(d) Formation of water



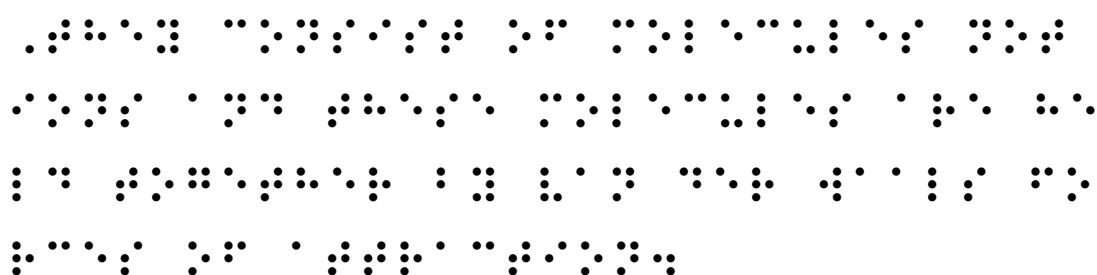
(e) Formation of hydrogen chloride



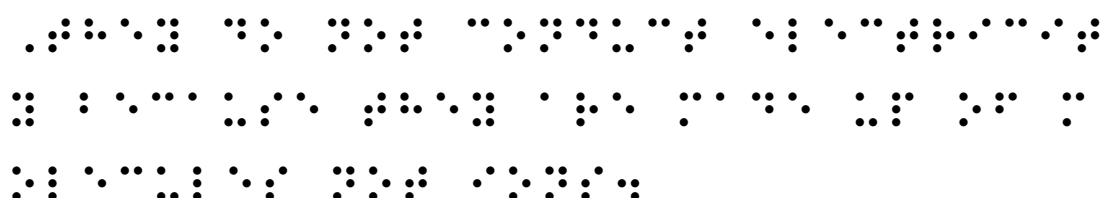
This is because covalent bonds are weak and require very little heat to break.



They consist of molecules not ions and these molecules are held together by van der Waals forces of attraction.

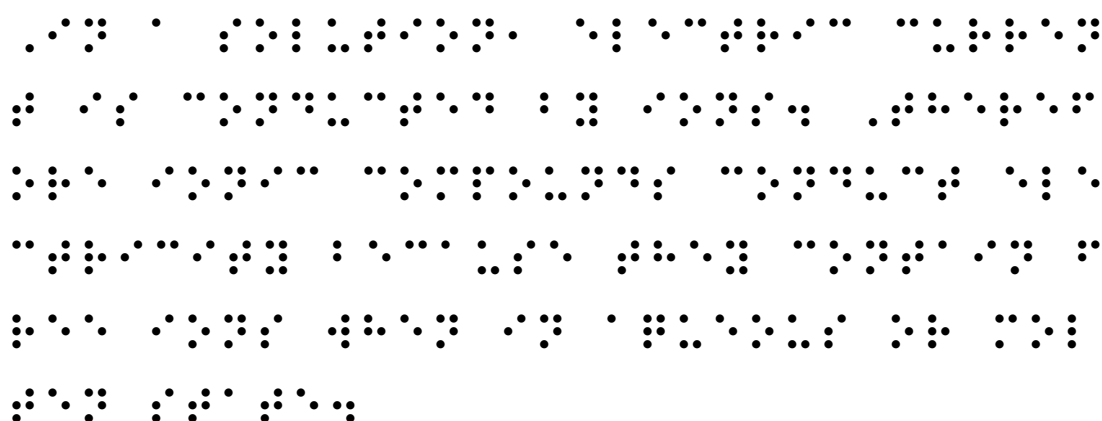


They do not conduct electricity because they are made up of molecules not ions.

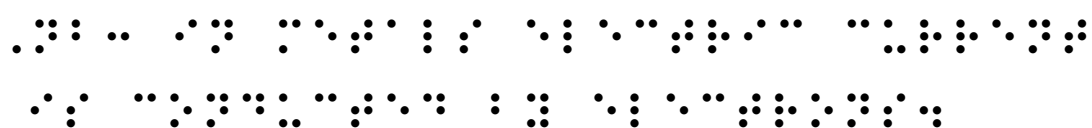


In a solution, electric current is conducted by ions.

Therefore ionic compounds conduct electricity because they contain free ions when in aqueous or molten state.



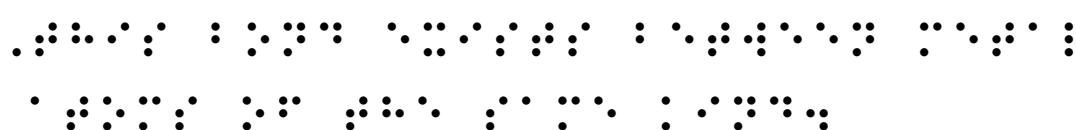
NB: In metals electric current is conducted by electrons.



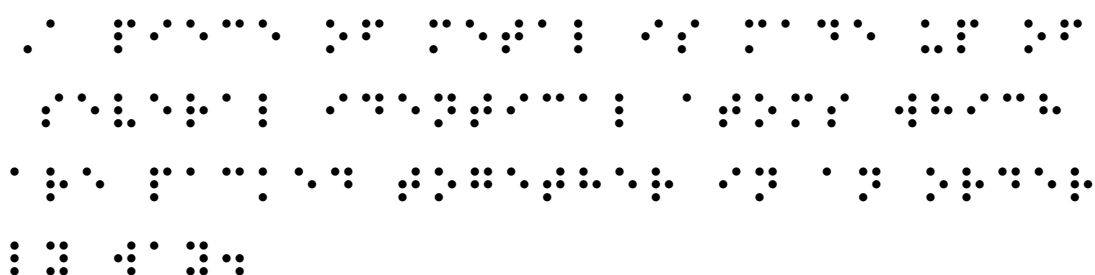
Metallic bonding



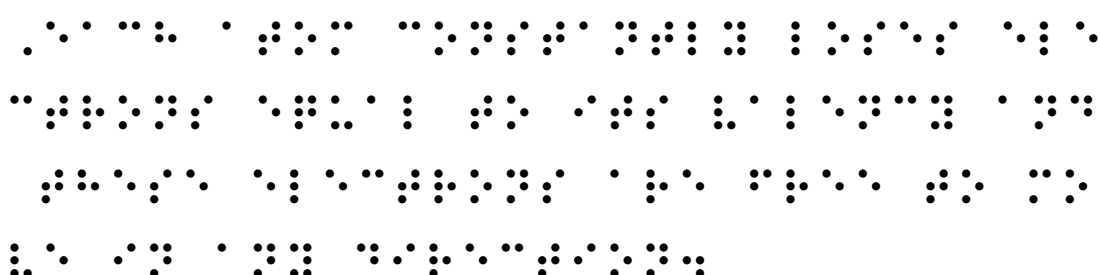
This bond exists between metal atoms of the same kind.



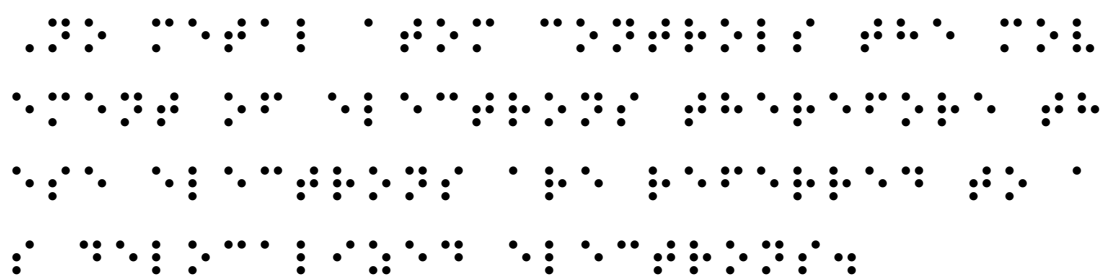
A piece of metal is made up of several identical atoms which are packed together in an orderly way.



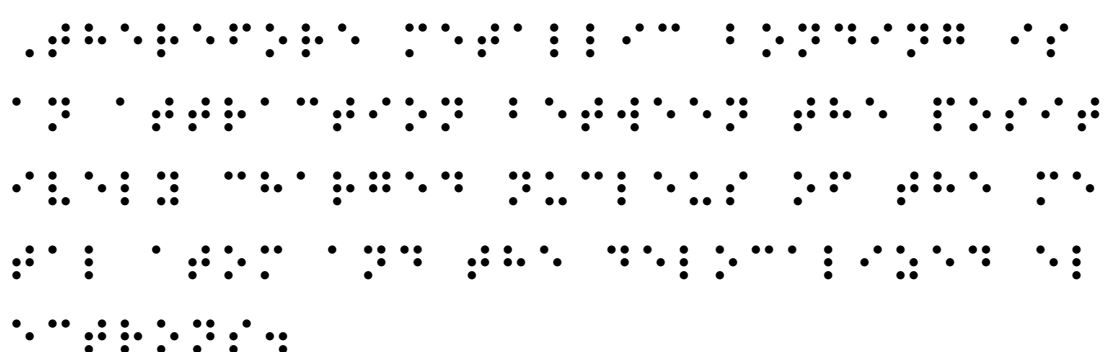
Each atom constantly loses electrons equal to its valency and these electrons are free to move in any direction.



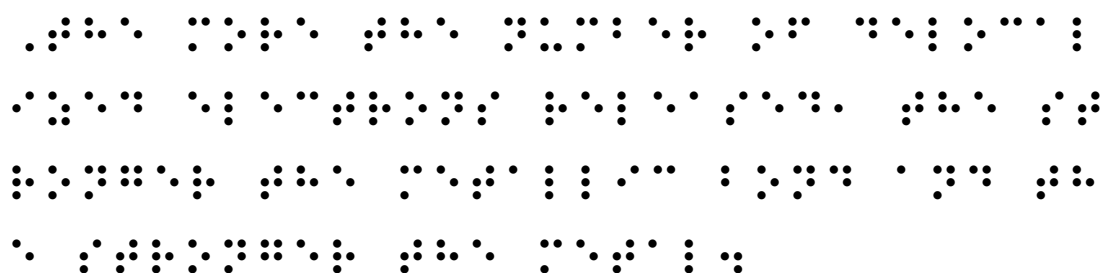
No metal atom controls the movement of electrons therefore these electrons are referred to as delocalized electrons.



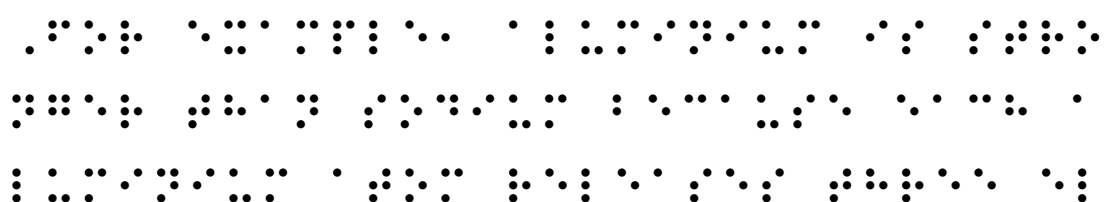
Therefore metallic bonding is an attraction between the positively charged nucleus of the metal atom and the delocalized electrons.



The more the number of delocalized electrons released, the stronger the metallic bond and the stronger the metal.



For example aluminium is stronger than sodium because each aluminium atom releases three electrons while each sodium atom releases only one electron.



[illegible]

This is why sodium metal is very soft and can be cut using a knife.

[illegible]

The mobile electrons are responsible for the conductivity of electricity and heat by metals.

B

A learner is given sodium and chlorine in the laboratory
 and asked to predict what compound will form.

Scenario : Understanding Bonding through Compound Formation

A learner is given sodium and chlorine in the laboratory
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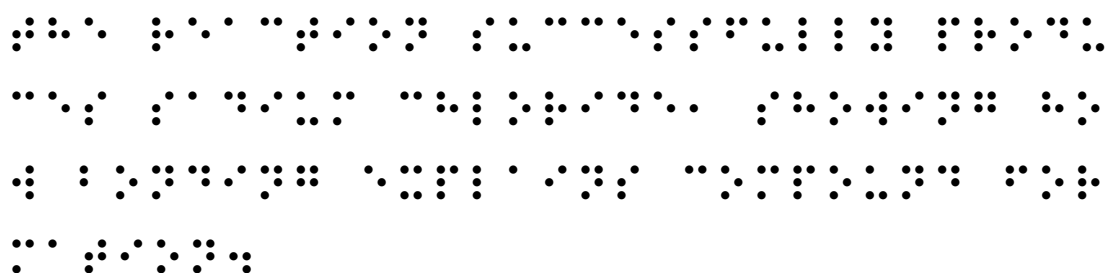
The learner remembers that sodium is highly reactive and
 chlorine is a non-metal.

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 chlorine is a non-metal.

He predicts that the atoms will combine by transferring
 electrons, forming an ionic compound.

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 electrons, forming an ionic compound.

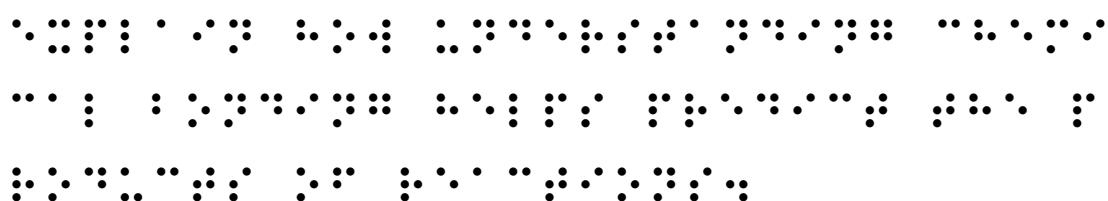
The reaction successfully produces sodium chloride, showing how bonding explains compound formation.



Assignment task:



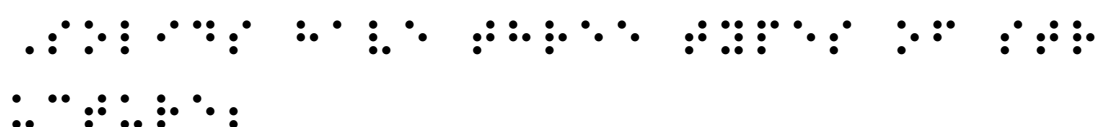
Explain how understanding chemical bonding helps predict the products of reactions.



Structure of solids



Solids have three types of structure;



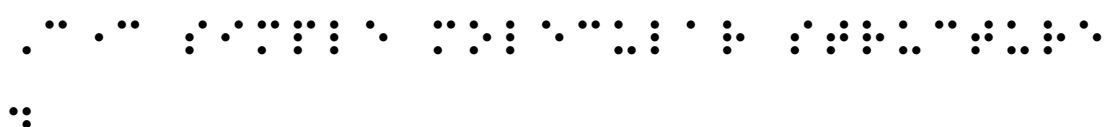
(a) Giant ionic structure.



(b) Giant atomic structure.



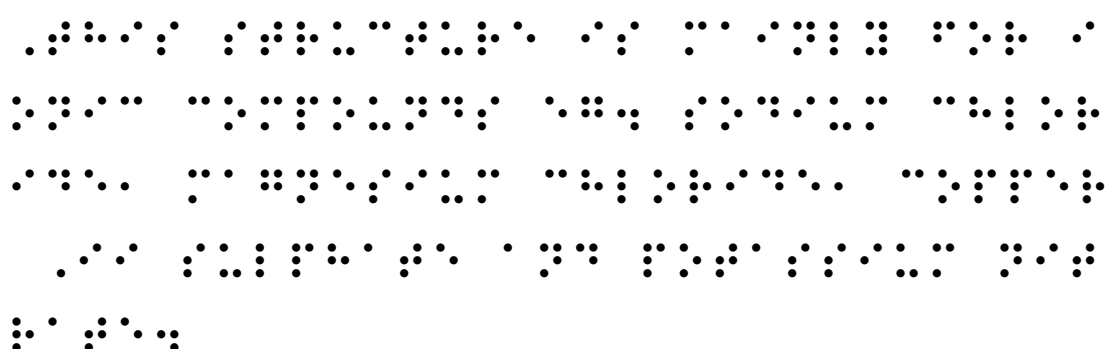
(c) Simple molecular structure.



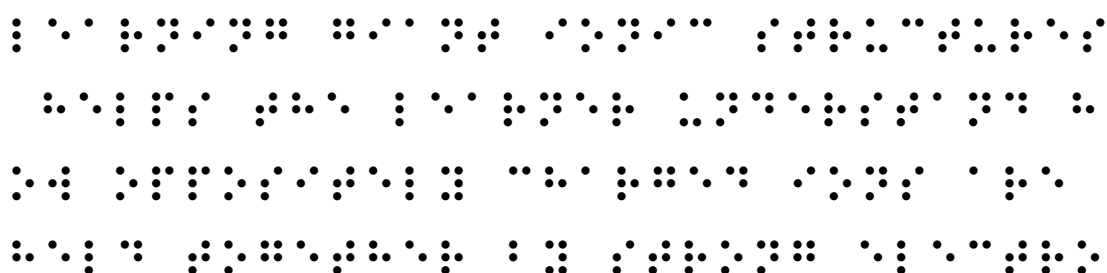
Giant ionic structure



This structure is mainly for ionic compounds e.g. sodium chloride, magnesium chloride, copper (II) sulphate and potassium nitrate.

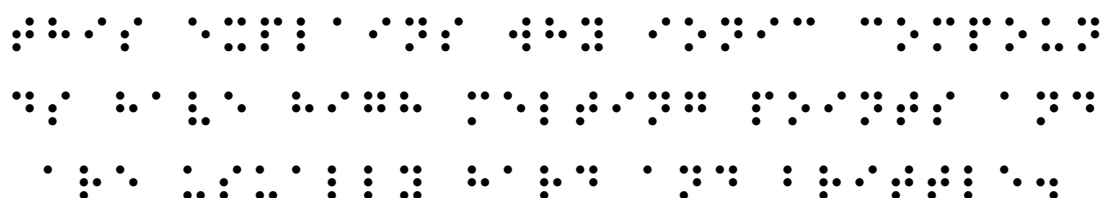


Learning giant ionic structures helps the learner understand how oppositely charged ions are held together by strong electrostatic forces in a regular lattice.

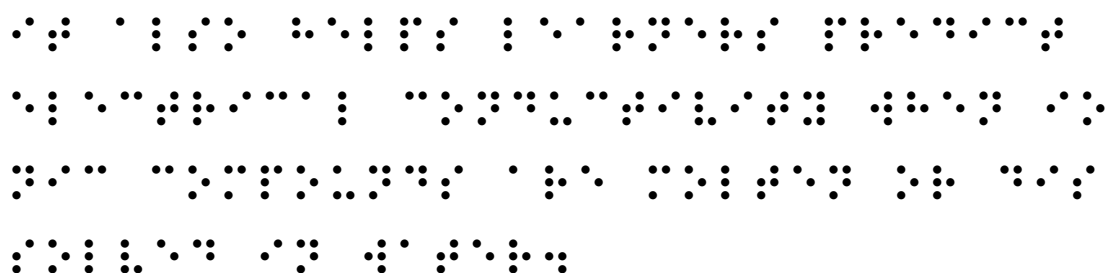




This explains why ionic compounds have high melting points and are usually hard and brittle.



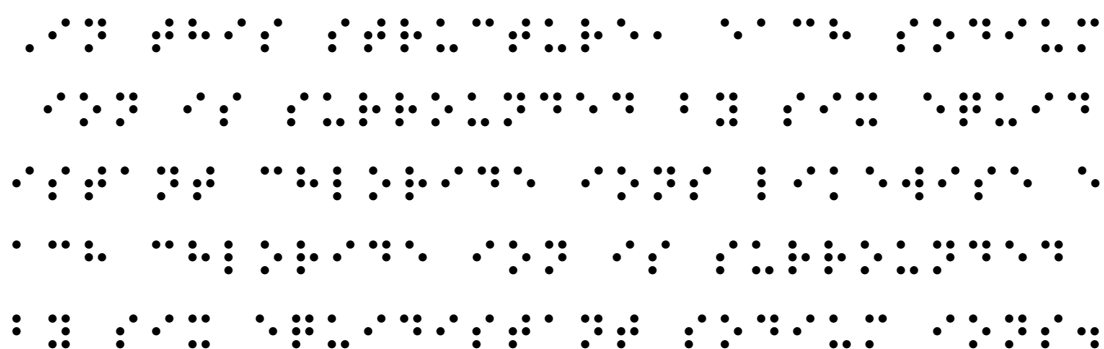
It also helps learners predict electrical conductivity when ionic compounds are molten or dissolved in water.



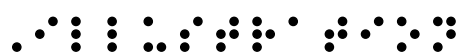
Structure of sodium chloride



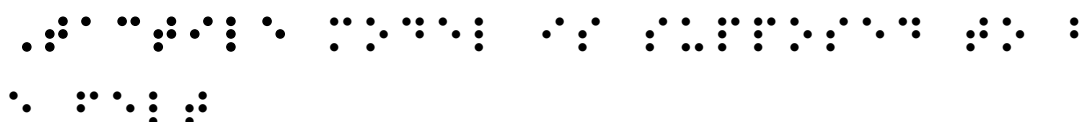
In this structure, each sodium ion is surrounded by six equidistant chloride ions likewise each chloride ion is surrounded by six equidistant sodium ions.



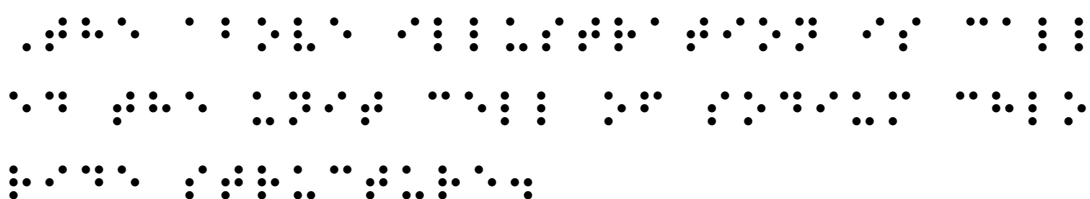
Illustration



TACTILE MODEL IS SUPPOSED TO BE FELT



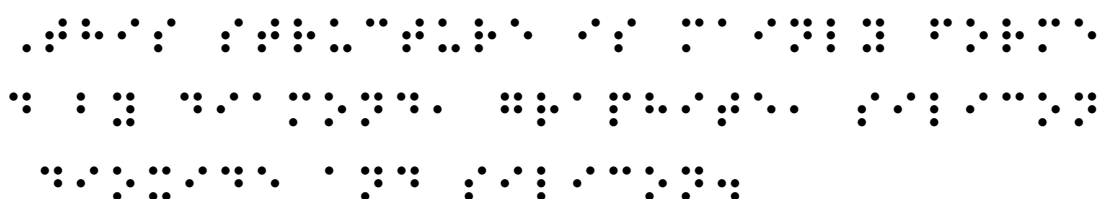
The above illustration is called the unit cell of sodium chloride structure.



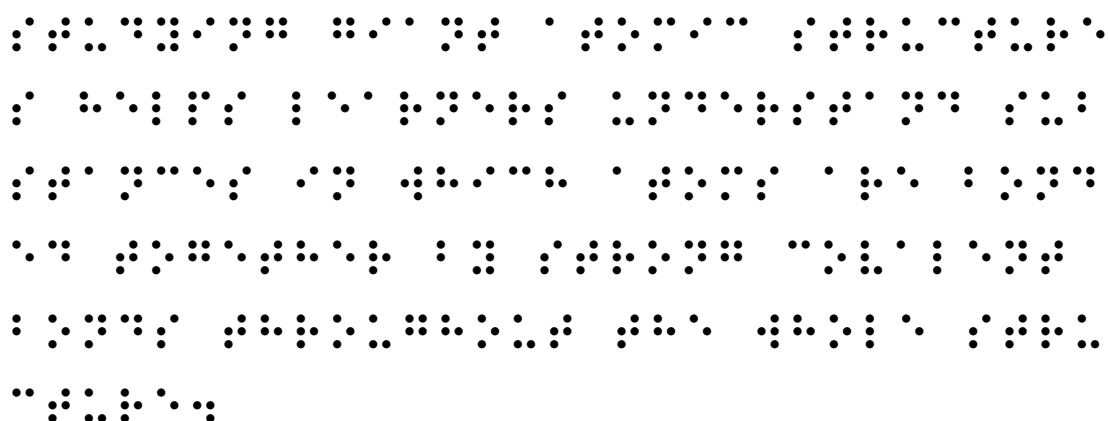
Giant atomic structure



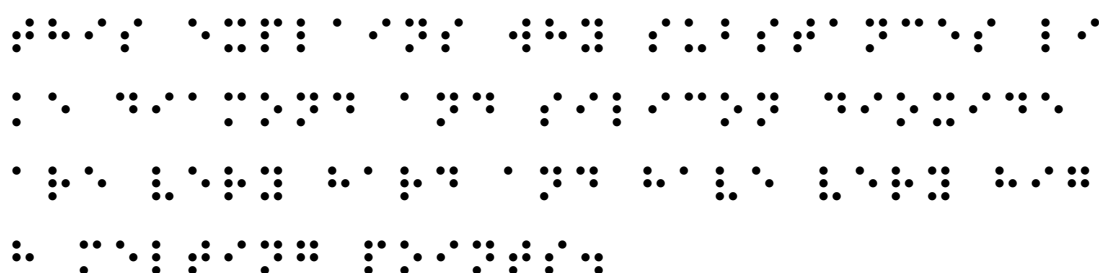
This structure is mainly formed by diamond, graphite, silicon dioxide and silicon.



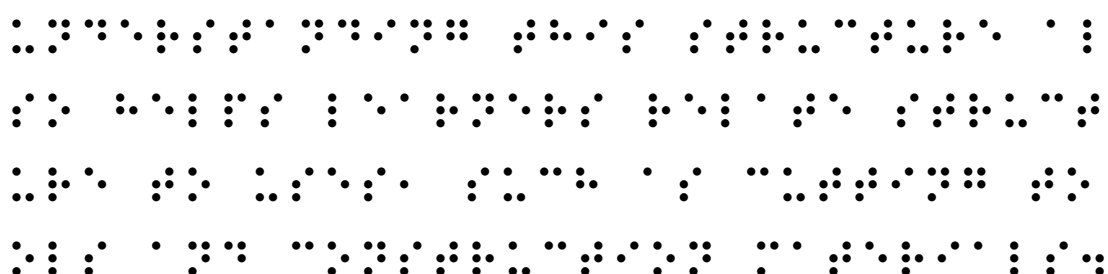
Studying giant atomic structures helps learners understand substances in which atoms are bonded together by strong covalent bonds throughout the whole structure.



This explains why substances like diamond and silicon dioxide are very hard and have very high melting points.



Understanding this structure also helps learners relate structure to uses, such as cutting tools and construction materials.



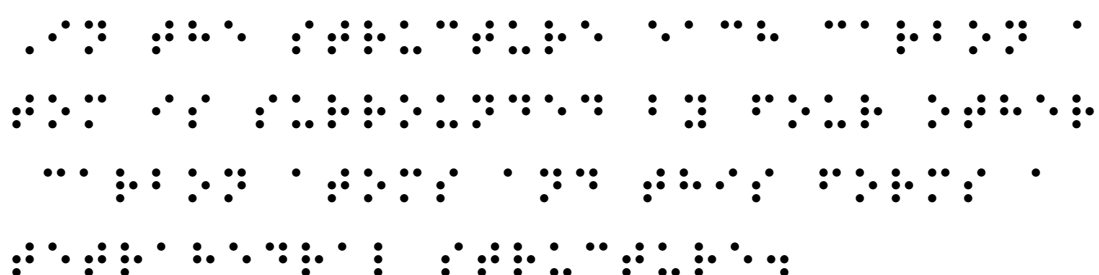
Consider diamond;



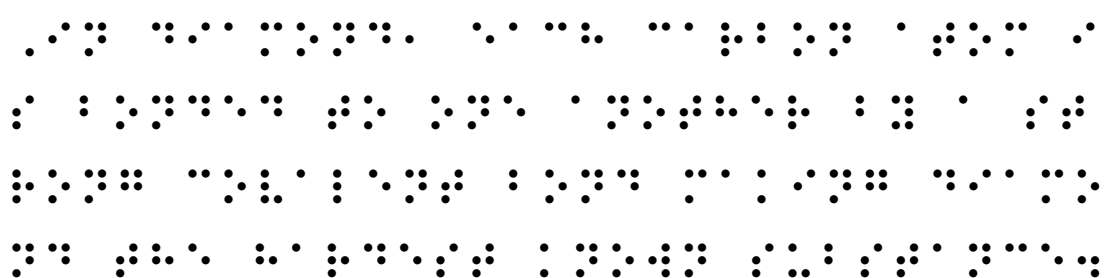
Diamond is a form of carbon.



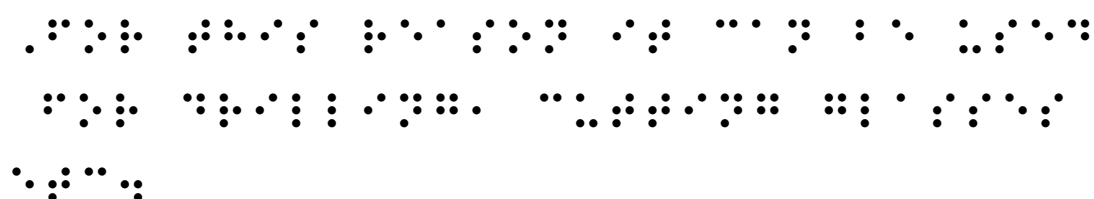
In the structure each carbon atom is surrounded by four other carbon atoms and this forms a tetrahedral structure.



In diamond, each carbon atom is bonded to one another by a strong covalent bond making diamond the hardest known substance.



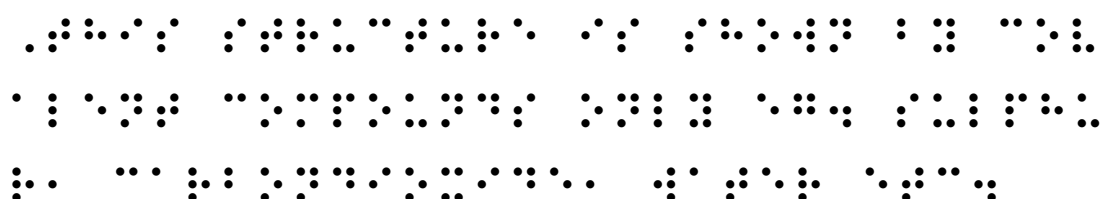
For this reason it can be used for drilling, cutting glasses etc.



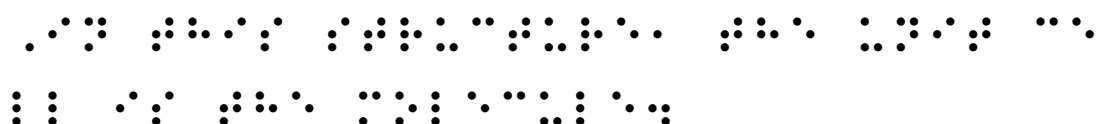
Simple molecular structure



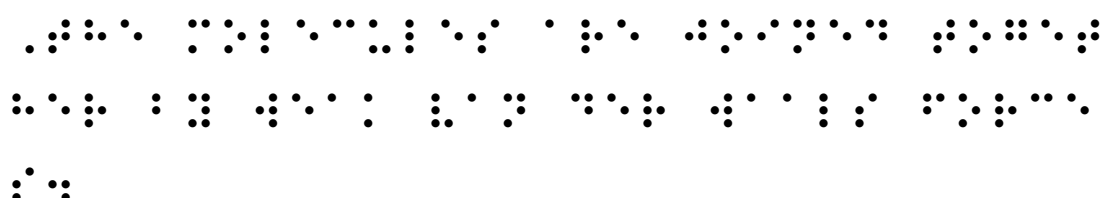
This structure is shown by covalent compounds only e.g. sulphur, carbondioxide, water etc.



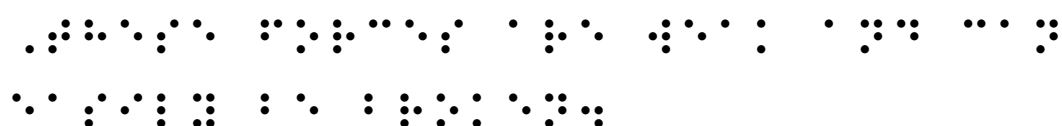
In this structure, the unit cell is the molecule.



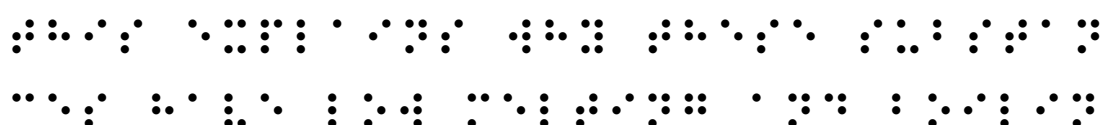
The molecules are joined together by weak van der waals forces.

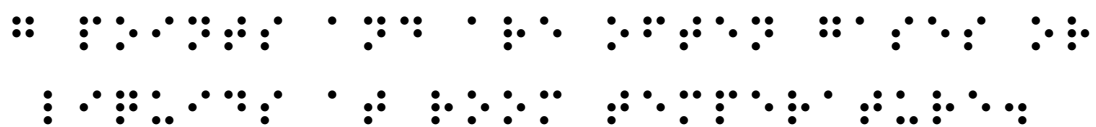


These forces are weak and can easily be broken.

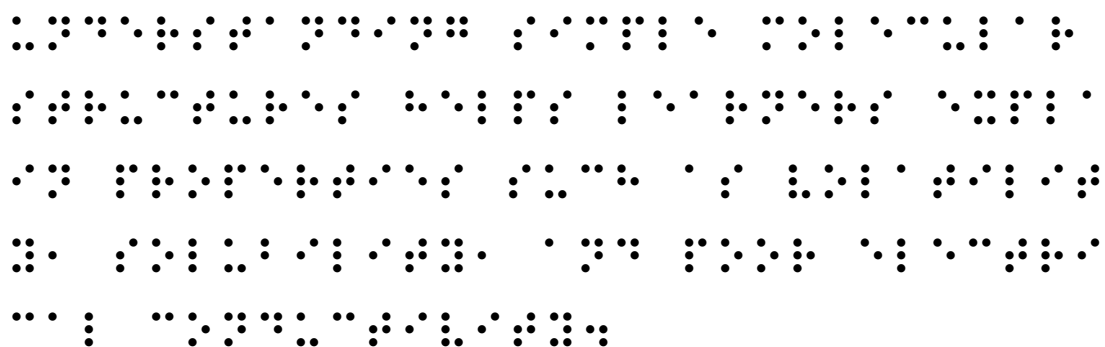


This explains why these substances have low melting and boiling points and are often gases or liquids at room temperature.





Understanding simple molecular structures helps learners explain properties such as volatility, solubility, and poor electrical conductivity.



It was developed in order to put together elements with similar chemical properties.

The first periodic table was developed by a Russian scientist called Mendeleev in the early 19th century.

According to Mendeleev, he classified all the elements according to their mass numbers or atomic masses but this criterion failed to categorize elements with similar chemical properties together because mass number does not determine the chemical properties of an element.

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However, in 1913, an English scientist called Mosley attempted to modify the periodic table of Mendeleev and he used atomic number to classify all the elements and all the elements with similar chemical properties found themselves together, and this periodic table was referred to as the modern periodic table.

The modern periodic table has a law called the periodic table law.

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It states that the chemical property of an element is a function of its atomic number.

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This means that the chemical property of an element is determined by the atomic number which is equal to the number of electrons that element contains.

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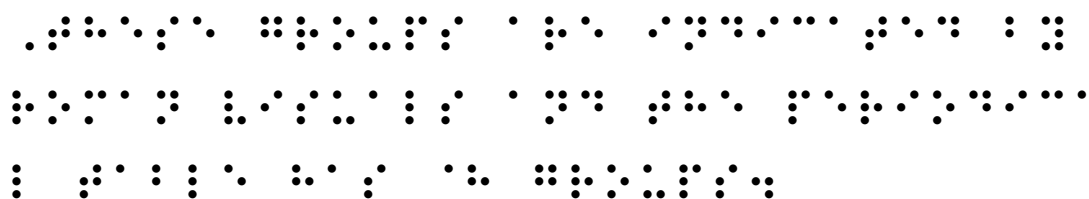
The periodic table is divided into groups and periods of the elements.

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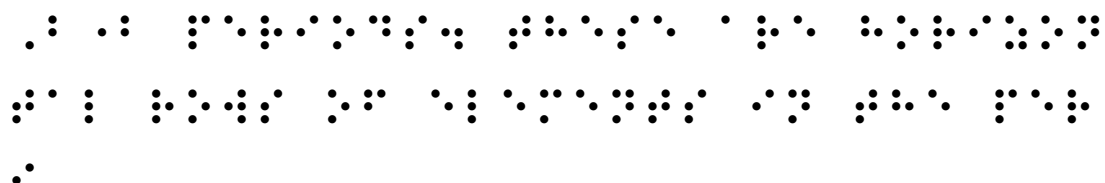
(a) Groups. These are vertical arrangements of elements into columns.

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These groups are indicated by Roman numerals and the periodic table has 8 groups.



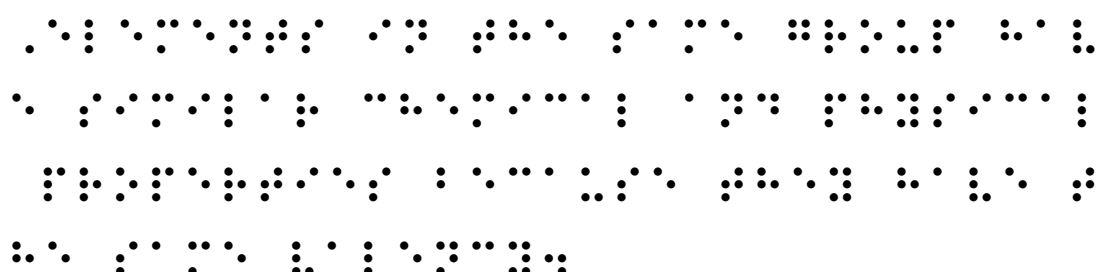
(b) Periods. These are horizontal rows of elements in the periodic table.



Characteristics of elements in the same group



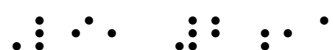
Elements in the same group have similar chemical and physical properties because they have the same valency.



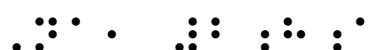
Group I elements



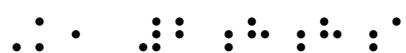
Li, 2:1



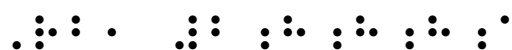
Na, 2:8:1



K, 2:8:8:1



Rb, 2:8:8:8:1



Fr, 2:8:8:8:8:1



Group 2 elements



Be, 2:2



Mg, 2:8:2



Ca, 2:8:8:2



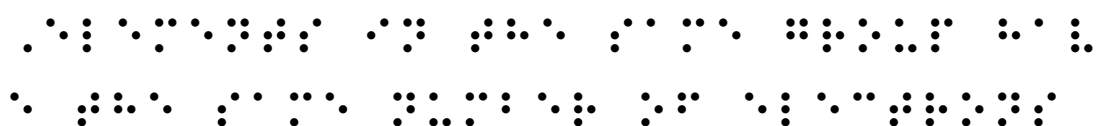
Sr, 2:8:8:8:2

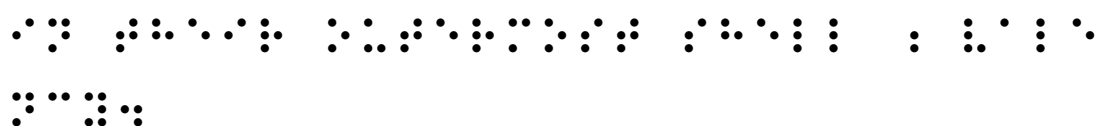


Ba, 2:8:8:8:8:2

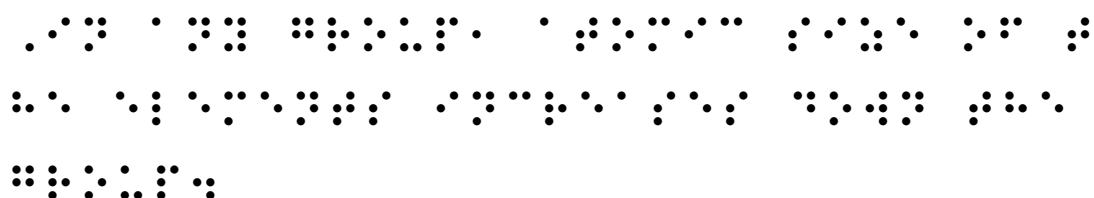


Elements in the same group have the same number of electrons in their outermost shell (valency).

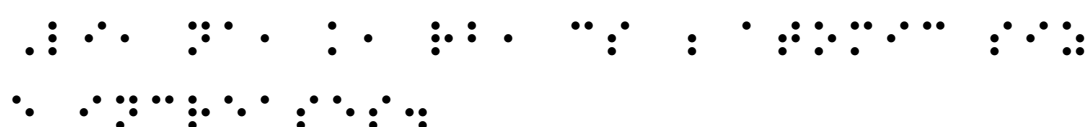




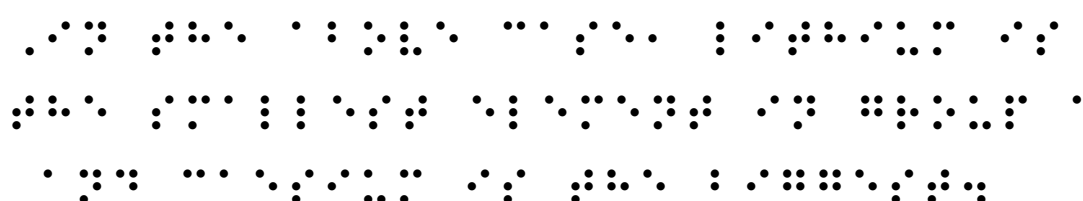
In any group, atomic size of the elements increases down the group.



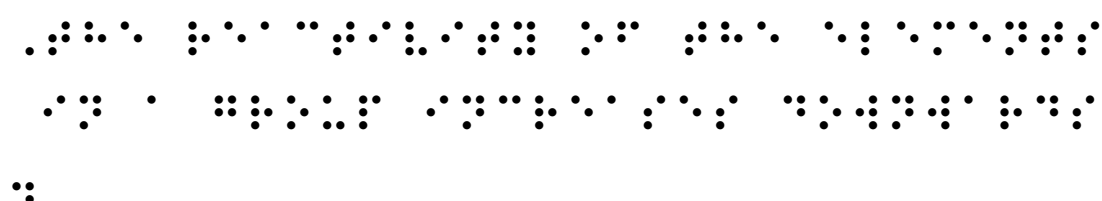
Li, Na, K, Rb, Cs – atomic size increases



In the above case, lithium is the smallest element in group 1 and caesium is the biggest.

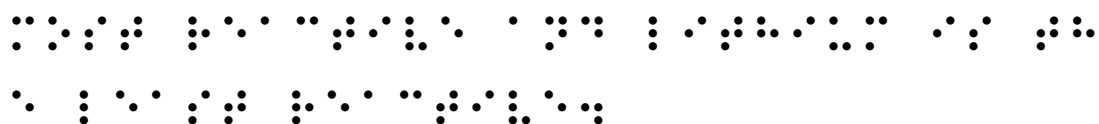


The reactivity of the elements in a group increases downwards.

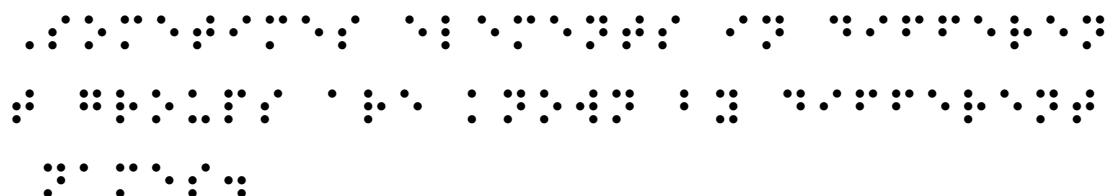


From the above, caesium is the most reactive and lithium is the least reactive.





Sometimes elements in different groups are known by different names.



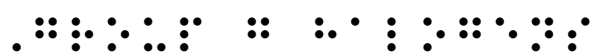
Group 1 – Alkali metals



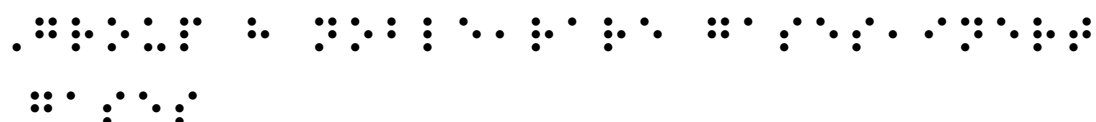
Group 2 – Alkaline earth metals



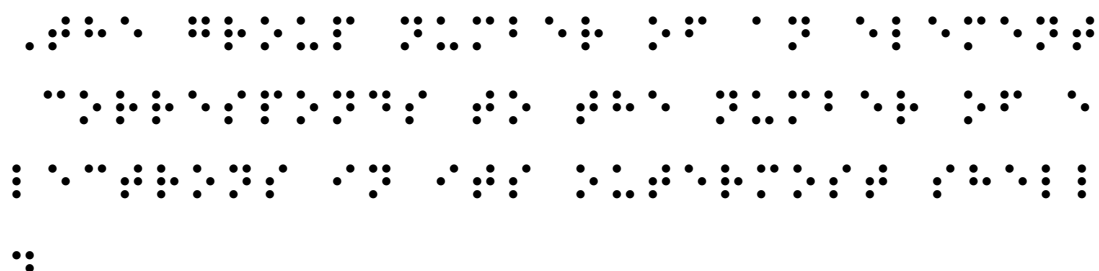
Group 7 – Halogens



Group 8 – Noble/rare gases/inert gases



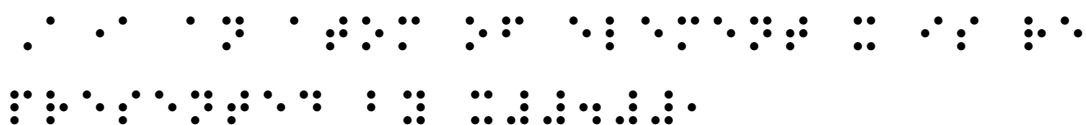
The group number of an element corresponds to the number of electrons in its outermost shell.



Example

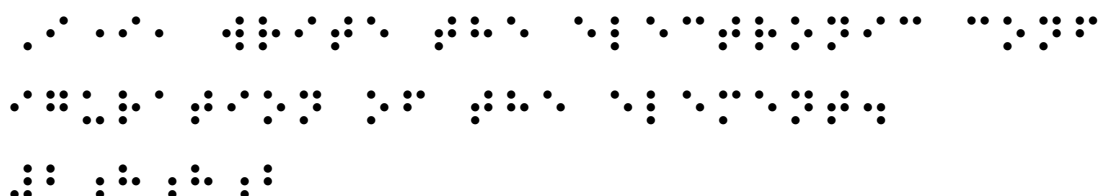


(a) An atom of element X is represented by X_{40}^{20}

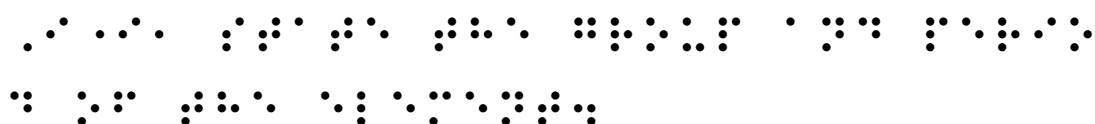


(i) Write the electronic configuration of the element:

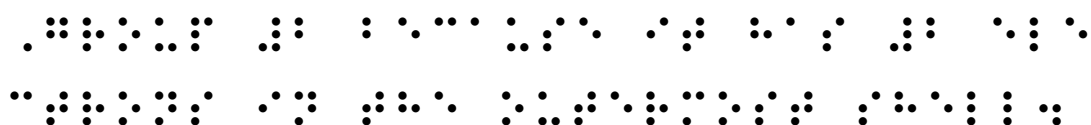
2:8:8:2



(ii) State the group and period of the element

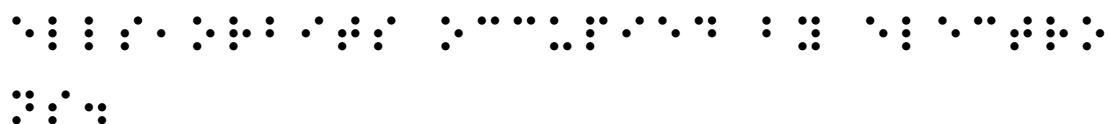


Group 2 because it has two electrons in the outermost shell

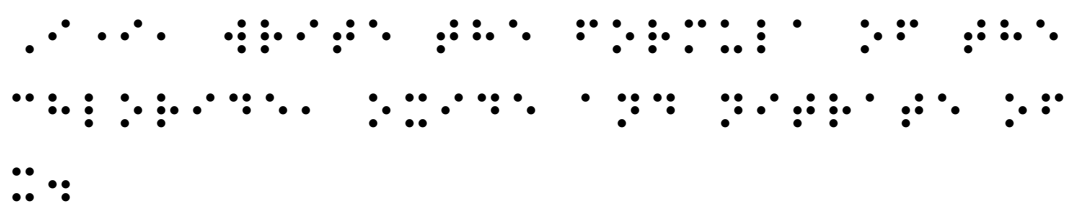


Period four because it has four shells/orbits occupied by electrons





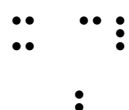
(iii) Write the formula of the chloride, oxide, and nitrate of X



Chloride

X Cl

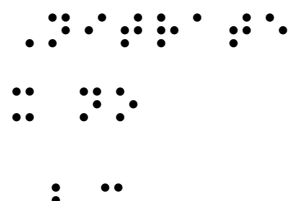
2



Nitrate

X NO

2 3

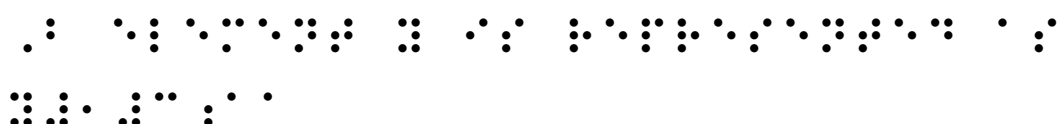


Oxide

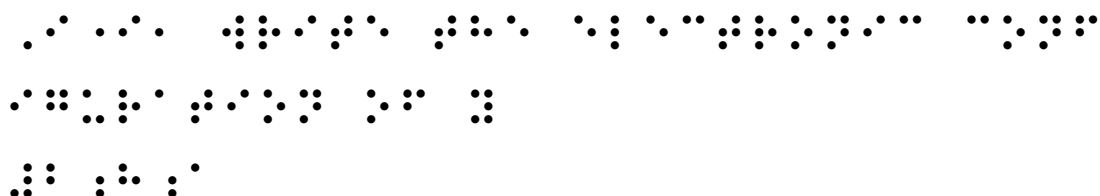
X O



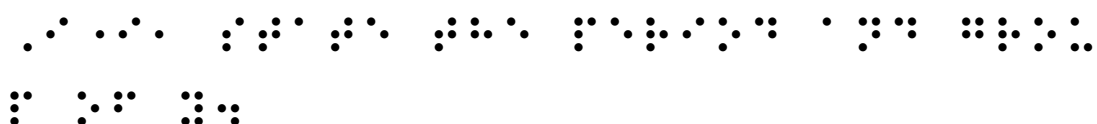
(b) Element Y is represented as Y_{23}^{11}



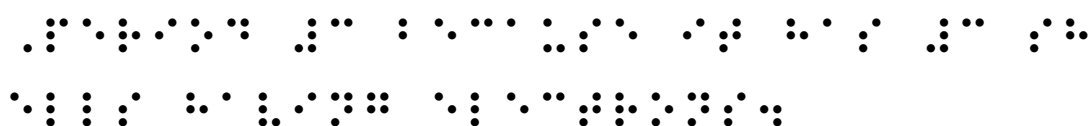
(i) Write the electronic configuration of Y: 2:8:1



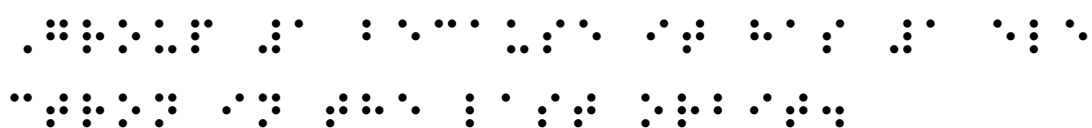
(ii) State the period and group of Y. Give reasons



Period three because it has three shells having electrons



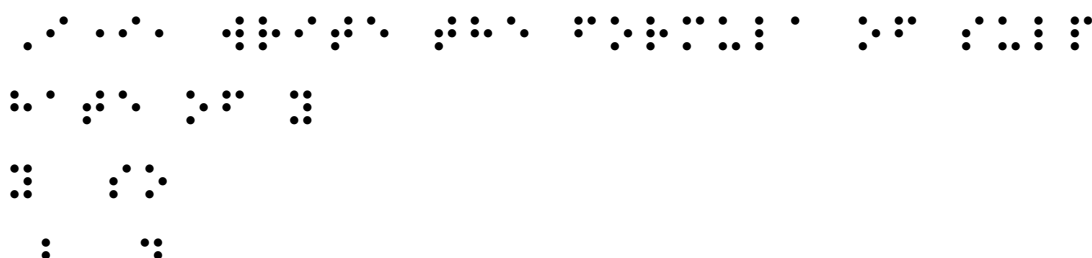
Group 1 because it has one electron in the last orbit/shell



(iii) Write the formula of sulphate of Y

Y SO

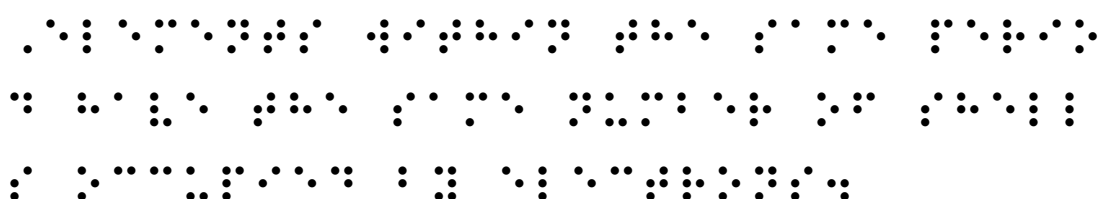
2 4



Characteristics of elements in the same period

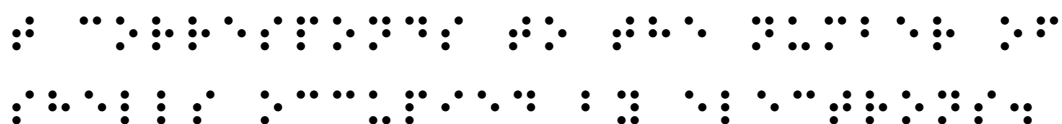


Elements within the same period have the same number of shells occupied by electrons.

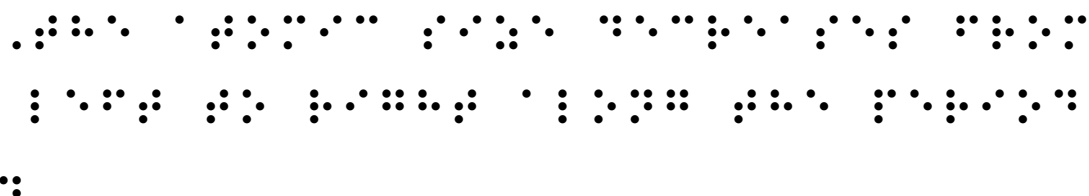


The period number of an element corresponds to the number of shells occupied by electrons.

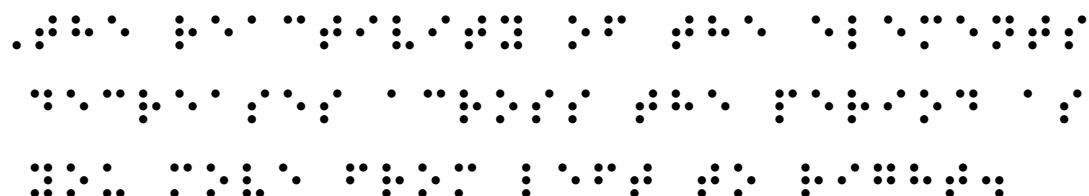




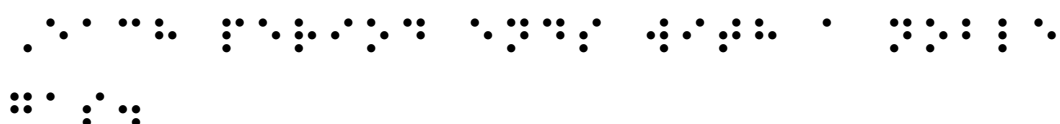
The atomic size decreases from left to right along the period.



The reactivity of the elements decreases across the period as you move from left to right.



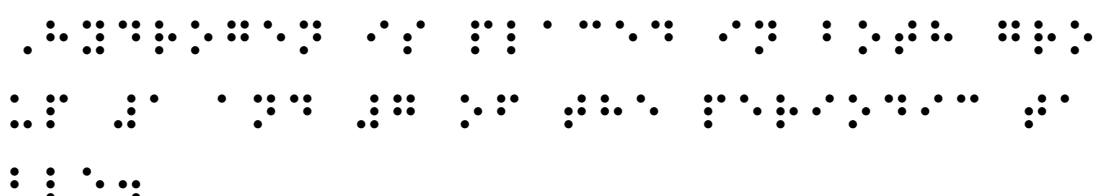
Each period ends with a noble gas.



Position of hydrogen



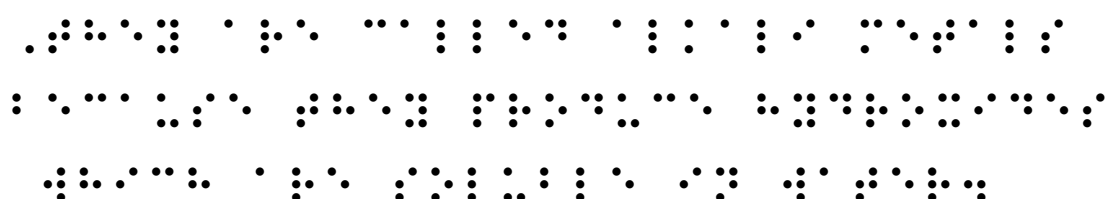
Hydrogen is placed in both group 1 and 7 of the periodic table.



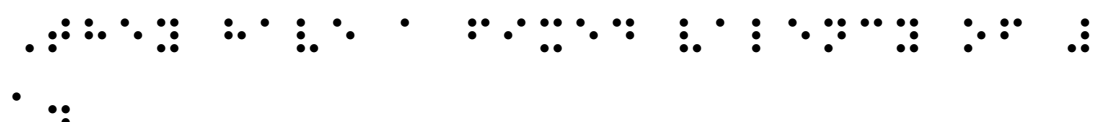
They are the most reactive metals.



They are called alkali metals because they produce hydroxides which are soluble in water (e.g., sodium hydroxide, potassium hydroxide).



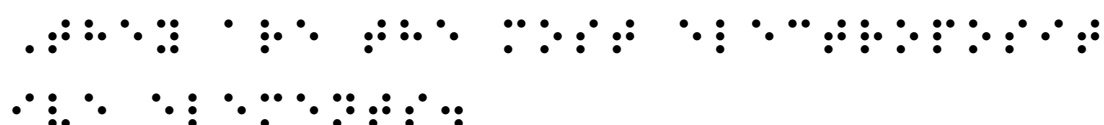
They have a fixed valency of 1.



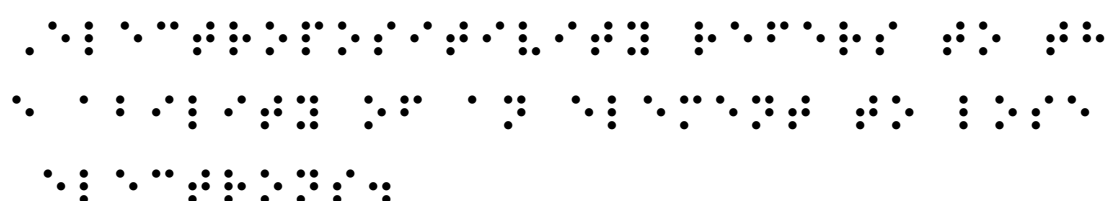
All their compounds are white in colour and soluble in water.



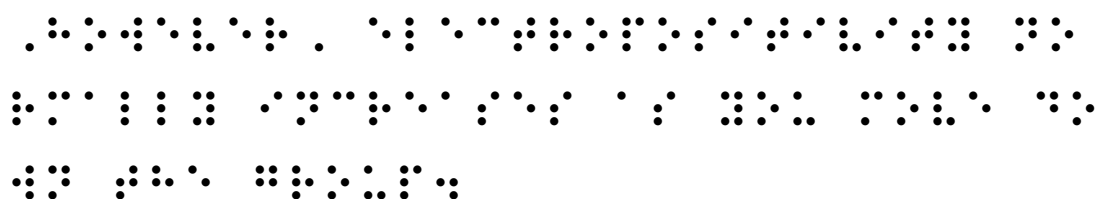
They are the most electropositive elements.



Electropositivity refers to the ability of an element to lose electrons.



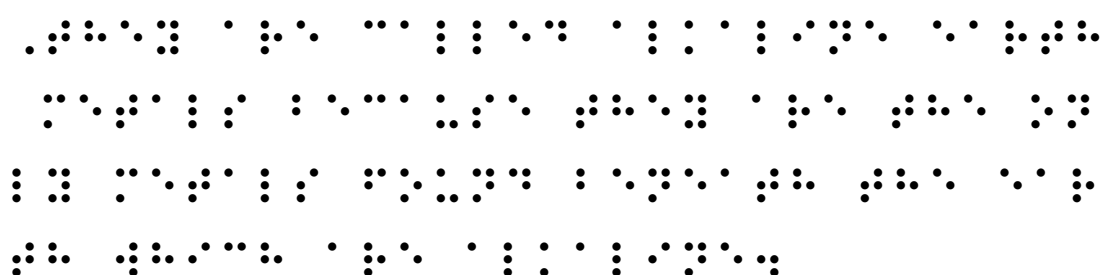
However, electropositivity normally increases as you move down the group.



Alkaline earth metals



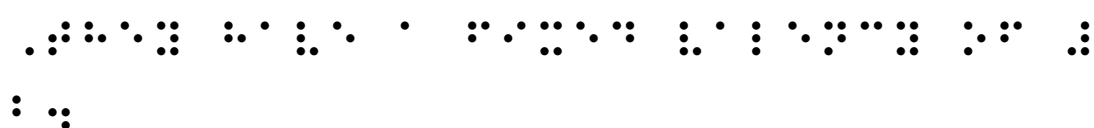
They are called alkaline earth metals because they are the only metals found beneath the earth which are alkaline.



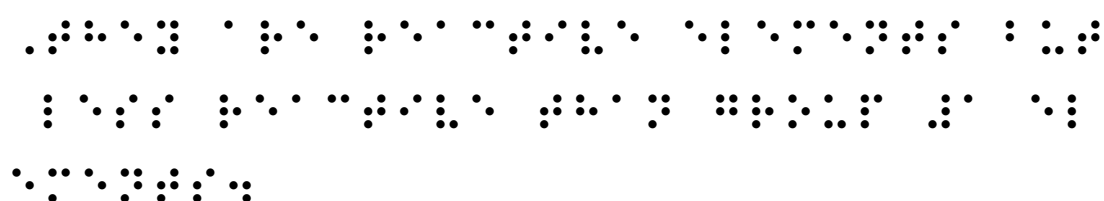
Characteristics:



They have a fixed valency of 2.



They are reactive elements but less reactive than group 1 elements.



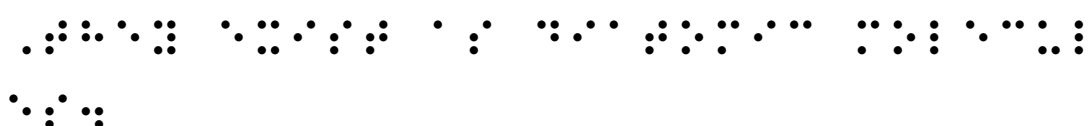
Halogens (group 7 elements)



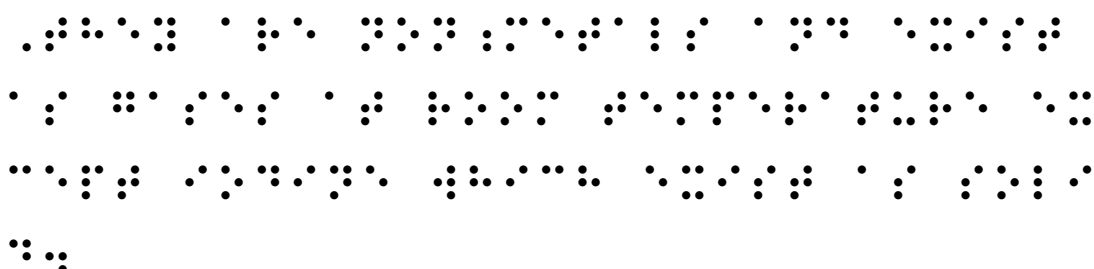
Characteristics:



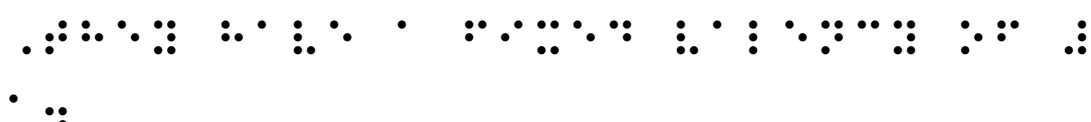
They exist as diatomic molecules.



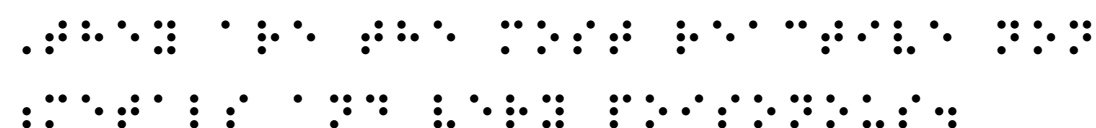
They are non-metals and exist as gases at room temperature except iodine which exists as solid.



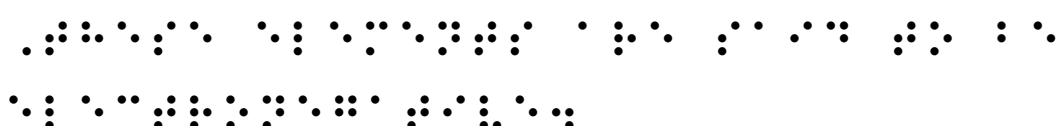
They have a fixed valency of 1.



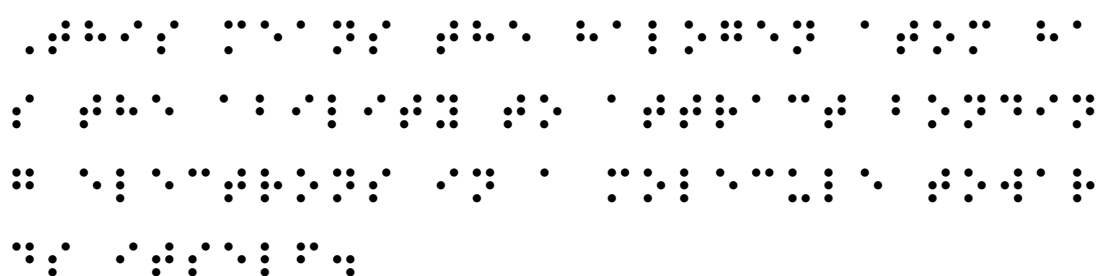
They are the most reactive non-metals and very poisonous.



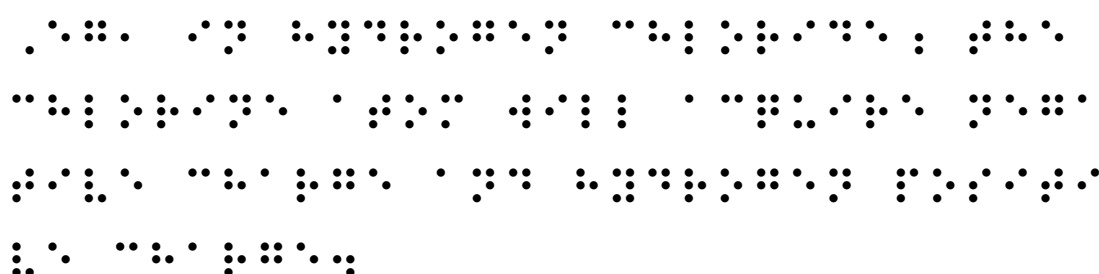
These elements are said to be electronegative.



This means the halogen atom has the ability to attract bonding electrons in a molecule towards itself.



Example: in hydrogen chloride, the chlorine atom will acquire negative charge and hydrogen positive charge.



Noble gases



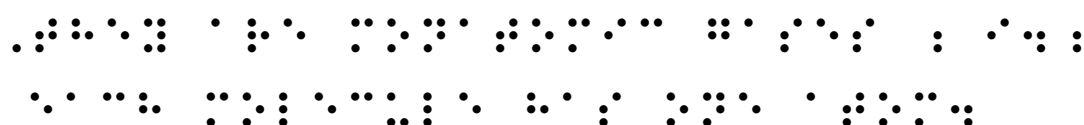
Characteristics:



They have a valency of zero.



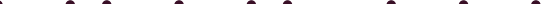
They are monatomic gases (i.e., each molecule has one atom).



They do not react because they have a valency of zero.

[illegible]

Transition elements



These are metals with special characteristics.

The Braille representation of the sentence "The cat sat on the mat." consists of two rows of dots. The first row contains the words "The", "cat", "sat", "on", "the", and "mat.", each followed by a space character. The second row continues the sentence with the same words and punctuation.

Examples of transition elements include copper, iron, nickel, manganese, etc.

[illegible]

Characteristic:

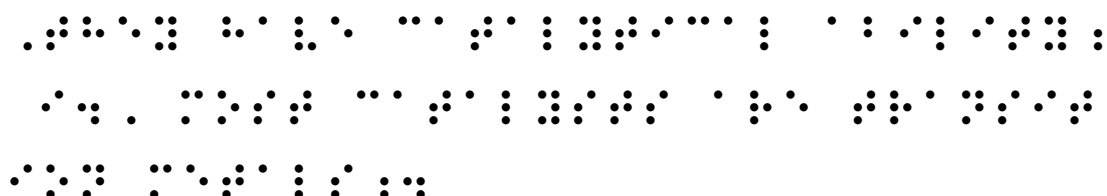
They have more than one valency while other elements have only one valency.

. 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 104

- Copper (II) nitrate is green



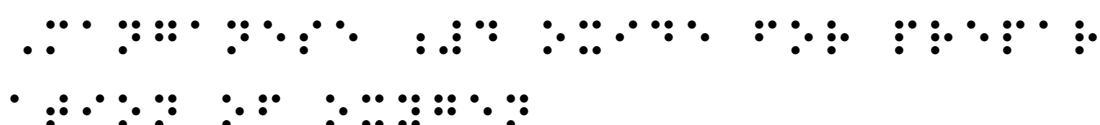
They have catalytic ability, i.e., most catalysts are transition metals/compounds.



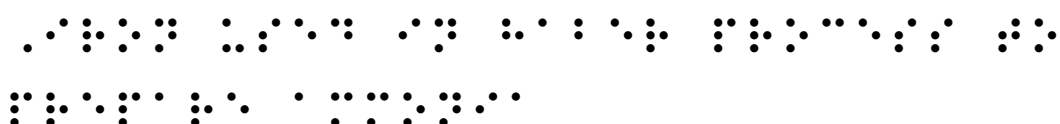
Examples of catalytic use:



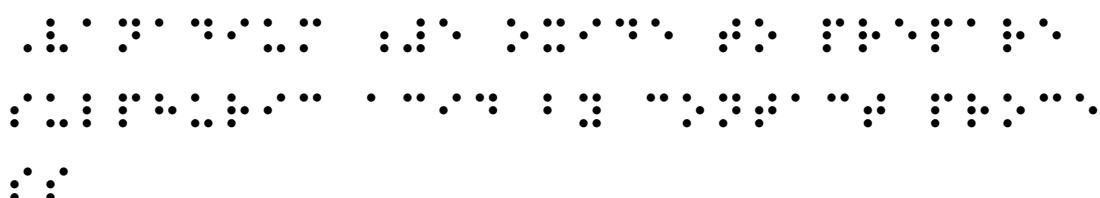
- Manganese (IV) oxide for preparation of oxygen



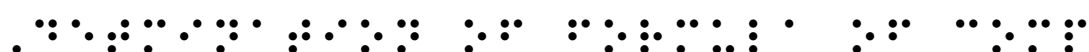
- Iron used in Haber process to prepare ammonia

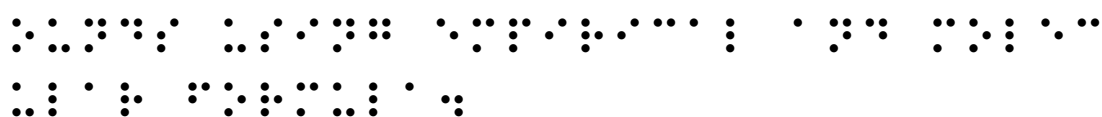


- Vanadium (V) oxide to prepare sulphuric acid by contact process

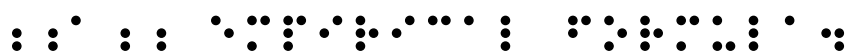


- Determination of formula of compounds using empirical and molecular formula

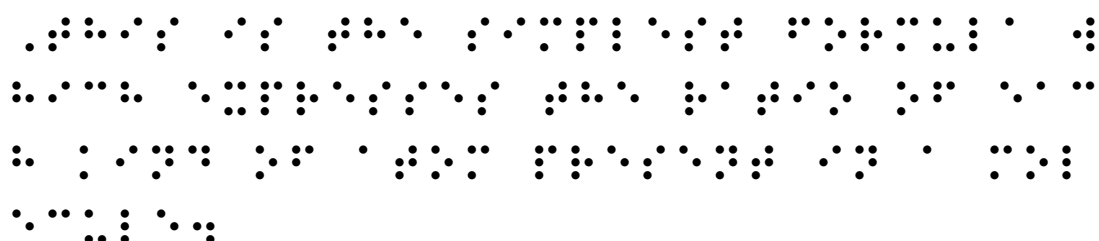




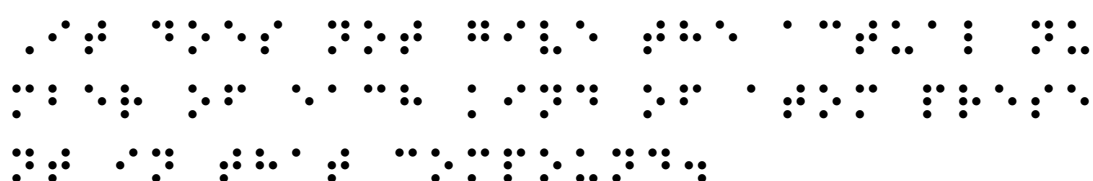
(a) Empirical formula:



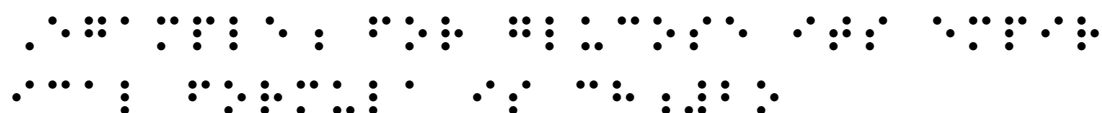
This is the simplest formula which expresses the ratio of each kind of atom present in a molecule.



It does not give the actual number of each kind of atom present in that compound.



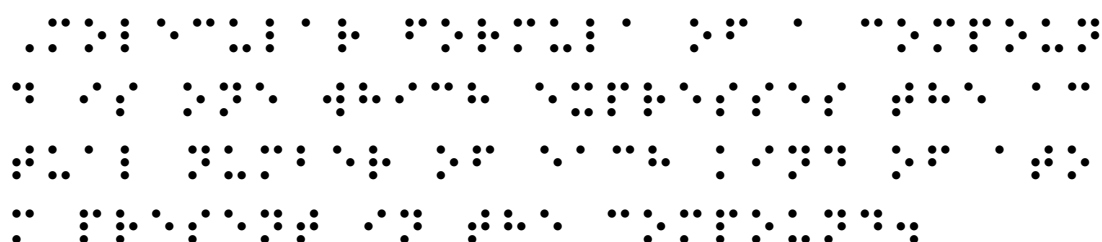
Example: for glucose its empirical formula is CH_2O .



(b) Molecular formula:



Molecular formula of a compound is one which expresses the actual number of each kind of atom present in the compound.



Sometimes certain compounds have the same empirical and molecular formula.

For example, glucose and fructose both have the molecular formula $C_6H_{12}O_6$ and the empirical formula $C_6H_{12}O_6$.

In general, empirical formula multiplied by whole number n gives the molar mass of the compound.

For example, the empirical formula of glucose is CH_2O and its molar mass is 180 g/mol . The molecular formula of glucose is $C_6H_{12}O_6$.

Molar mass of a compound

The molar mass of a compound is the mass of one mole of the compound.

This is the mass obtained by adding the mass of all the atoms present in the compound.

For example, the molar mass of glucose is 180 g/mol . This is calculated by adding the mass of all the atoms in the molecular formula $C_6H_{12}O_6$.

The molecular formula is normally used to determine mass if the empirical formula is known.

For example, the empirical formula of glucose is CH_2O . The molecular formula of glucose is $C_6H_{12}O_6$.

In order to determine the molar mass of a compound, the relative atomic mass of each atom must be given.

For example, to determine the molar mass of water, we need to know the relative atomic mass of hydrogen and oxygen. The relative atomic mass of hydrogen is 1 and the relative atomic mass of oxygen is 16. Therefore, the molar mass of water is $2 \times 1 + 16 = 18$ g/mol.

Relative atomic mass of an element is the mass of one atom of the element divided by 1/12th the mass of one atom of carbon-12.

For example, the relative atomic mass of hydrogen is 1 because the mass of one hydrogen atom is 1/12th the mass of one carbon-12 atom. The relative atomic mass of oxygen is 16 because the mass of one oxygen atom is 16/12th the mass of one carbon-12 atom.

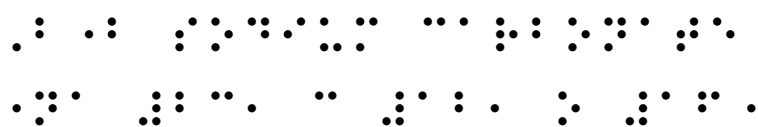
Relative atomic mass is a ratio; therefore it does not have units.

For example, the relative atomic mass of hydrogen is 1 and the relative atomic mass of oxygen is 16. Therefore, the relative atomic mass of water is $2 \times 1 + 16 = 18$.

Determining molar mass given relative atomic masses

For example, to determine the molar mass of water, we need to know the relative atomic mass of hydrogen and oxygen. The relative atomic mass of hydrogen is 1 and the relative atomic mass of oxygen is 16. Therefore, the molar mass of water is $2 \times 1 + 16 = 18$ g/mol.

(Na = 23, C = 12, O = 16)

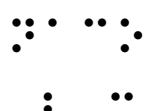


Formula



Na CO

2 3



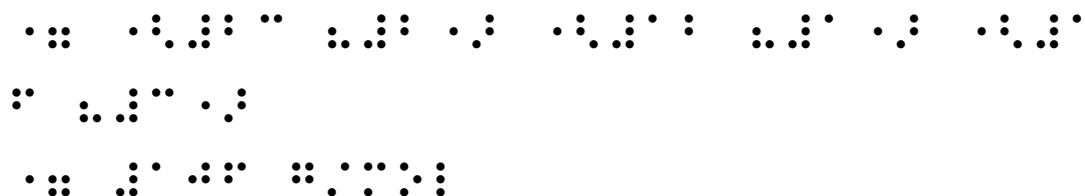
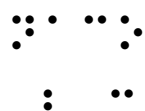
Calculation



Na₂CO₃

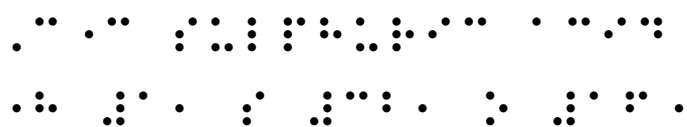
$$= (23 \times 2) + (12 \times 1) + (16 \times 3)$$

$$= 106 \text{ g/mol}$$



(c) Sulphuric acid

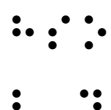
(H = 1, S = 32, O = 16)



Formula


$$H \quad SO$$

2 4

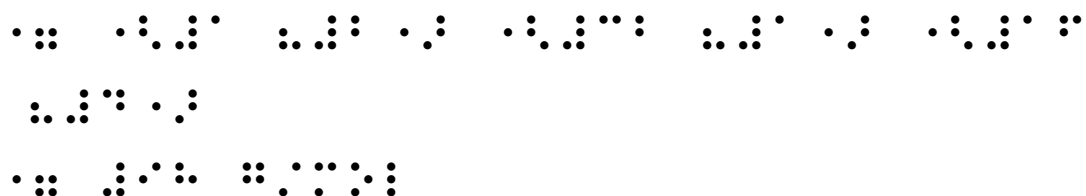
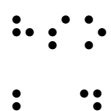


Calculation


$$\text{H}_2\text{SO}_4$$

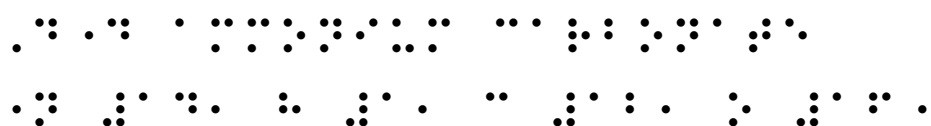
$$= (1 \times 2) + (32 \times 1) + (16 \times 4)$$

$$= 98 \text{ g/mol}$$

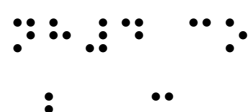


(d) Ammonium carbonate

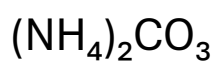
(N = 14, H = 1, C = 12, O = 16)



Formula

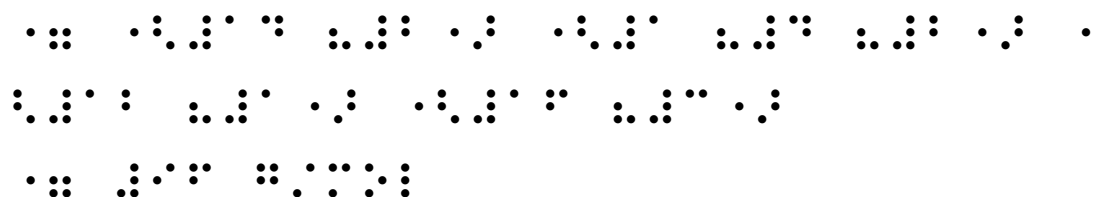
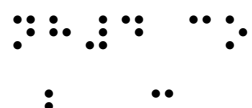


Calculation

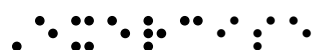


$$= (14 \times 2) + (1 \times 4 \times 2) + (12 \times 1) + (16 \times 3)$$

$$= 96 \text{ g/mol}$$



Exercise



$\frac{\text{Mass of element}}{\text{Relative atomic mass of element}} \times 100$
 $\frac{\text{Mass of element}}{\text{Relative atomic mass of element}} \times 100$

In order to determine the empirical formula of a compound, the percentage composition of the elements in the compound must be given and also the relative atomic masses of the elements should be given.

$\frac{\text{Mass of element}}{\text{Relative atomic mass of element}} \times 100$
 $\frac{\text{Mass of element}}{\text{Relative atomic mass of element}} \times 100$
 $\frac{\text{Mass of element}}{\text{Relative atomic mass of element}} \times 100$
 $\frac{\text{Mass of element}}{\text{Relative atomic mass of element}} \times 100$
 $\frac{\text{Mass of element}}{\text{Relative atomic mass of element}} \times 100$
 $\frac{\text{Mass of element}}{\text{Relative atomic mass of element}} \times 100$
 $\frac{\text{Mass of element}}{\text{Relative atomic mass of element}} \times 100$

Example

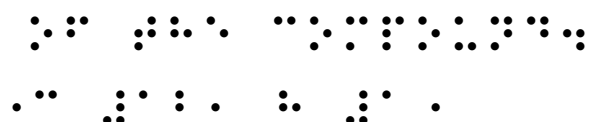
$\frac{\text{Mass of element}}{\text{Relative atomic mass of element}} \times 100$

A compound contains 20% by mass of hydrogen and 80% by mass of carbon.

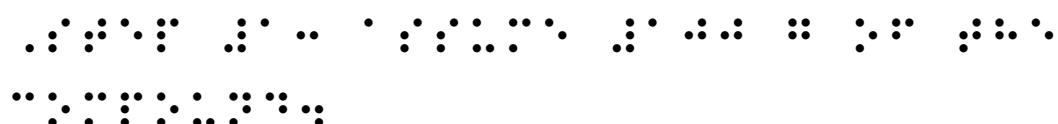
Determine the empirical formula of the compound.

(C = 12, H = 1)

$\frac{\text{Mass of element}}{\text{Relative atomic mass of element}} \times 100$
 $\frac{\text{Mass of element}}{\text{Relative atomic mass of element}} \times 100$
 $\frac{\text{Mass of element}}{\text{Relative atomic mass of element}} \times 100$
 $\frac{\text{Mass of element}}{\text{Relative atomic mass of element}} \times 100$



Step 1: Assume 100 g of the compound



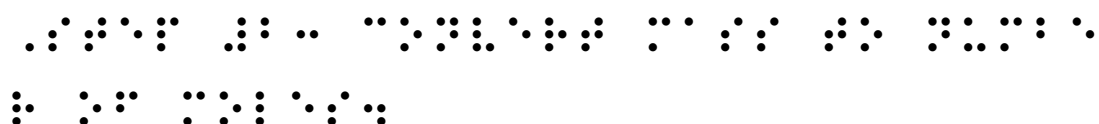
Mass of carbon = 80 g



Mass of hydrogen = 20 g



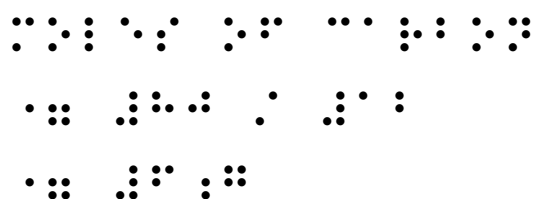
Step 2: Convert mass to number of moles



Moles of carbon

$$= 80 \div 12$$

$$= 6.7$$



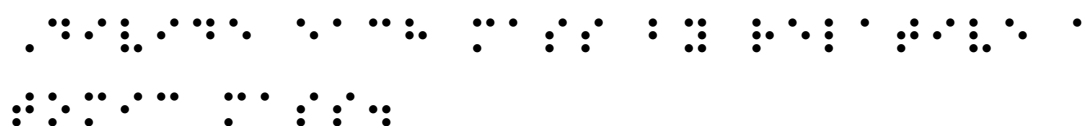
$$O = 30.4 \text{ g}$$



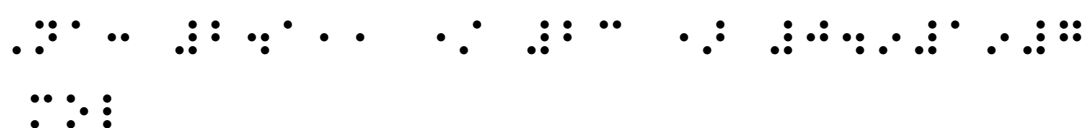
Step 2: Convert mass to moles



Divide each mass by relative atomic mass:



$$\text{Na: } 21.1 \div 23 \approx 0.917 \text{ mol}$$



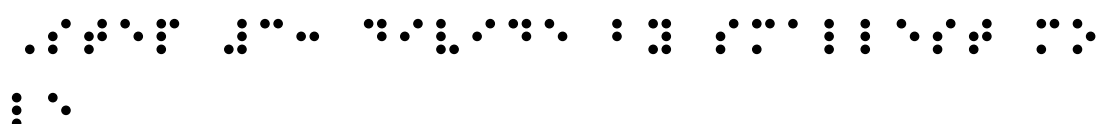
S: $40.5 \div 32 \approx 1.266 \text{ mol}$



$$\text{O: } 30.4 \div 16 = 1.9 \text{ mol}$$

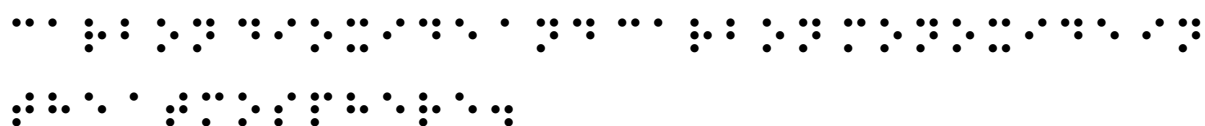


Step 3: Divide by smallest mole



Smallest mole = 0.917





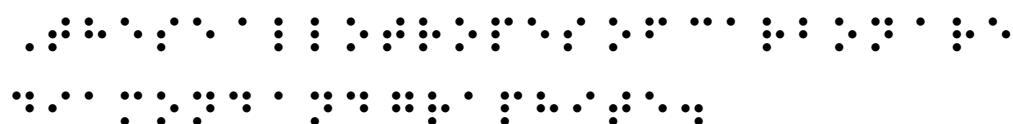
Forms of Carbon



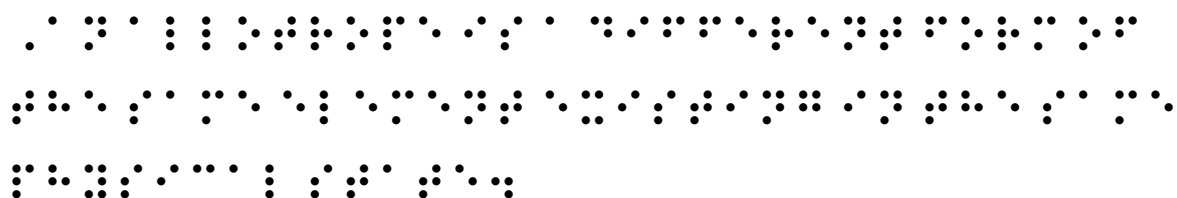
Carbon exists in two main forms known as allotropes.



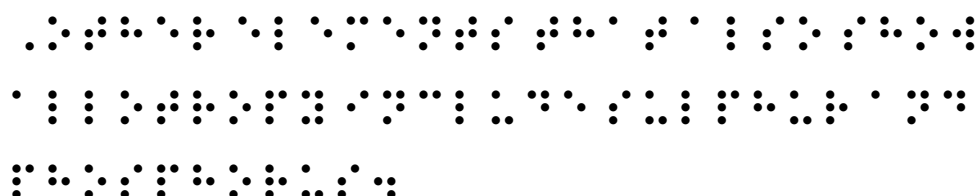
These allotropes of carbon are diamond and graphite.



An allotrope is a different form of the same element existing in the same physical state.



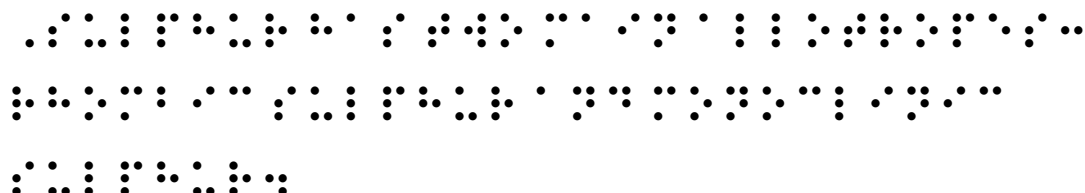
Other elements that also show allotropy include sulphur and phosphorus.



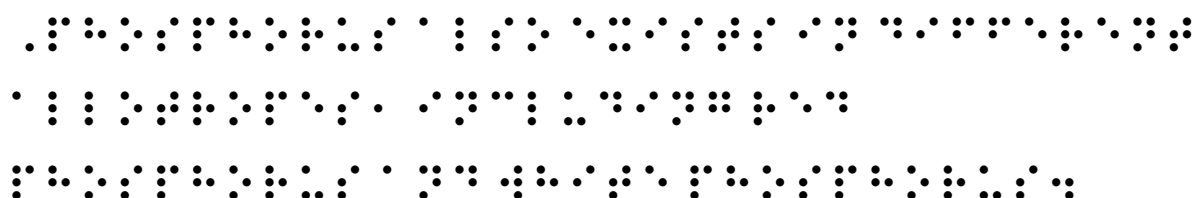
Elements and Their Allotropes



Sulphur has two main allotropes: rhombic sulphur and monoclinic sulphur.



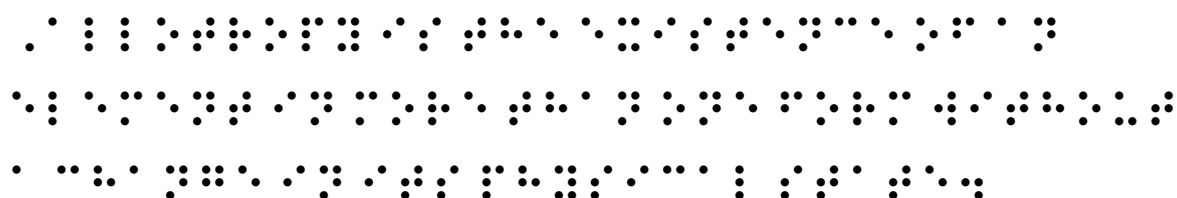
Phosphorus also exists in different allotropes, including red phosphorus and white phosphorus.



Allotropy



Allotropy is the existence of an element in more than one form without a change in its physical state.



Another form of carbon is known as amorphous carbon, for example charcoal.

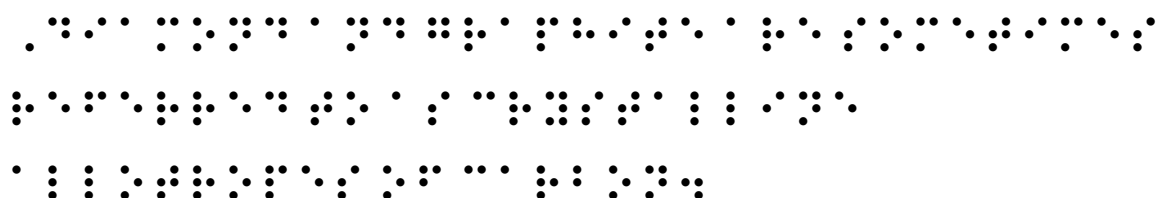




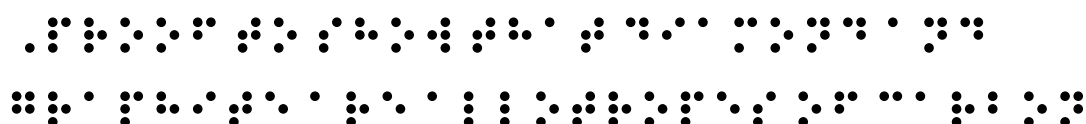
Note



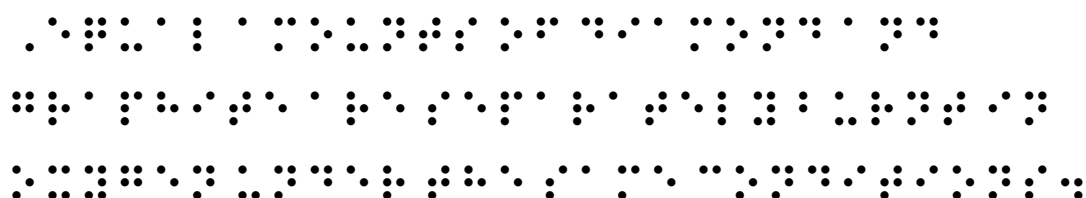
Diamond and graphite are sometimes referred to as crystalline allotropes of carbon.



Proof to show that diamond and graphite are allotropes of carbon



Equal amounts of diamond and graphite are separately burnt in oxygen under the same conditions.

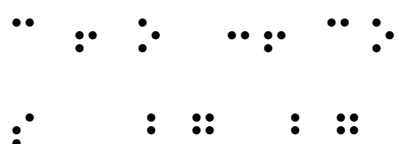
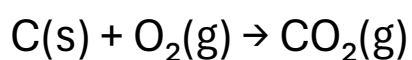
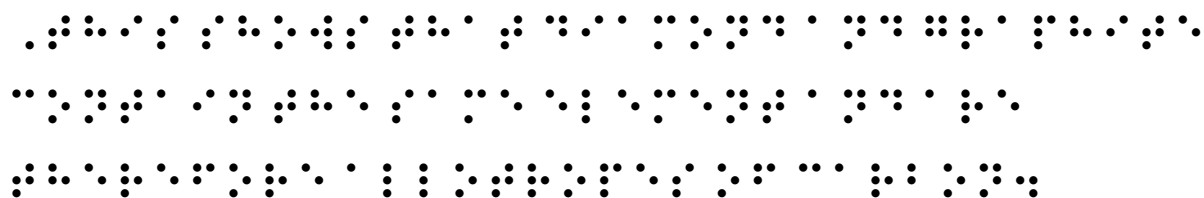


The same volume of carbon dioxide is produced when both substances are burnt.





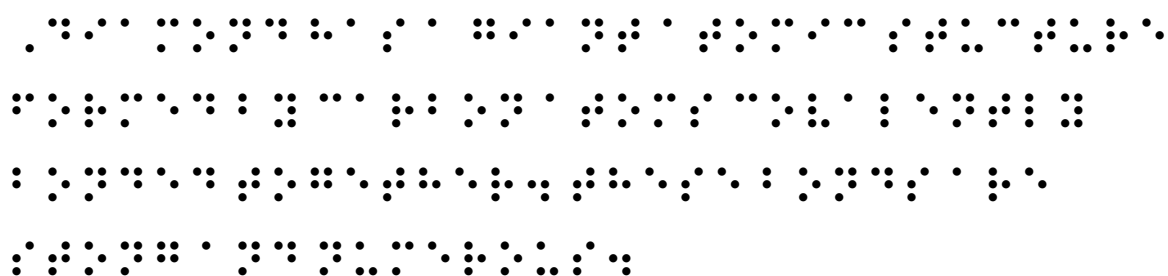
This shows that diamond and graphite contain the same element and are therefore allotropes of carbon.



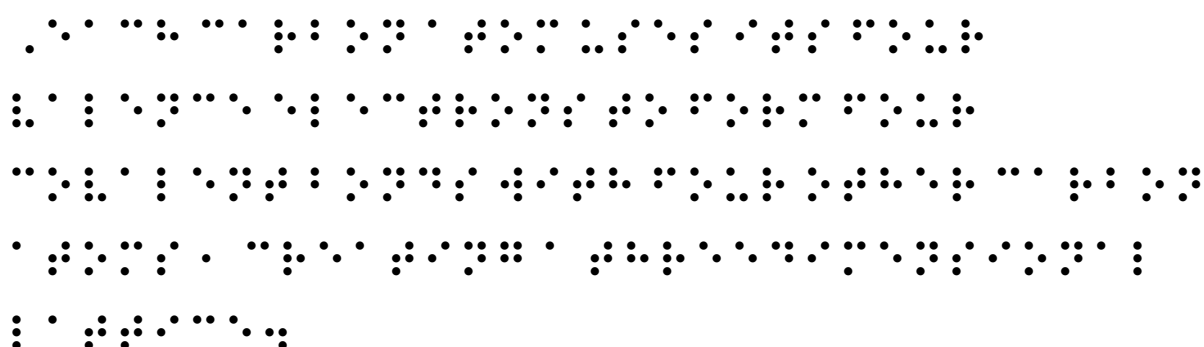
Structure of Diamond



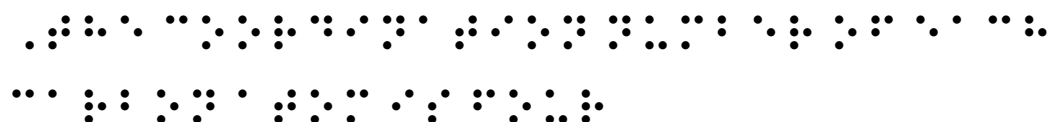
Diamond has a giant atomic structure formed by carbon atoms covalently bonded together. These bonds are strong and numerous.



Each carbon atom uses its four valence electrons to form four covalent bonds with other carbon atoms, creating a three-dimensional lattice.



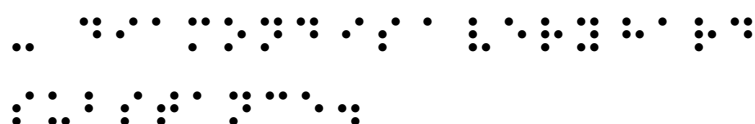
The coordination number of each carbon atom is four, meaning each atom is surrounded by four others.



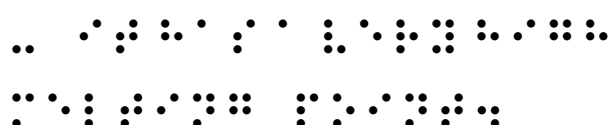
Properties of Diamond



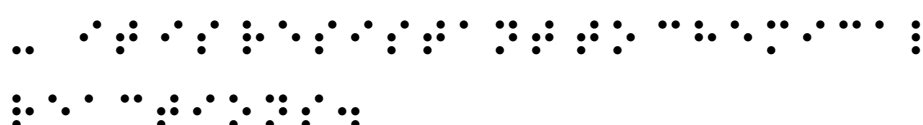
- Diamond is a very hard substance.



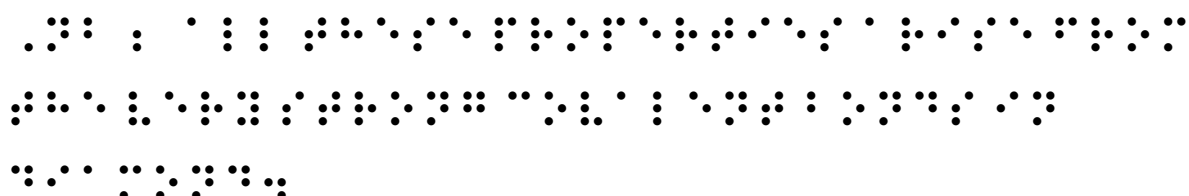
- It has a very high melting point.



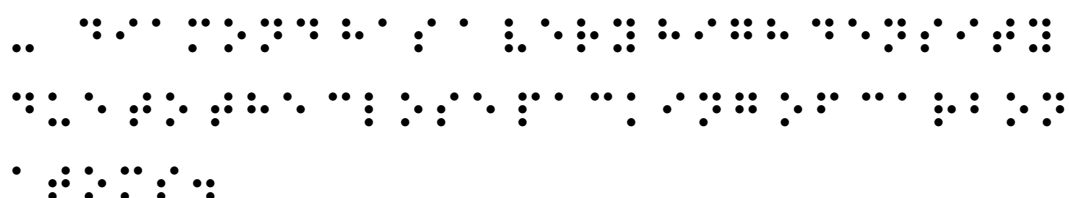
- It is resistant to chemical reactions.



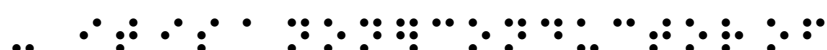
NB: All these properties arise from the very strong covalent bonds in diamond's structure.



- Diamond has a very high density due to the close packing of carbon atoms.



- It is a non-conductor of electricity due to the absence of mobile (delocalized) electrons.



Diamond is a form of carbon in which each carbon atom is tetrahedrally bonded to four other carbon atoms, forming a three-dimensional network of strong covalent bonds.

Uses of Diamond

Diamond has several important uses:

- Used in the manufacture of glass cutters.

Because diamond is the hardest known substance, it is used to cut and grind other materials.

- Used in the manufacture of drilling machines.

Diamond drill bits are used to drill holes in hard materials like concrete and metal.

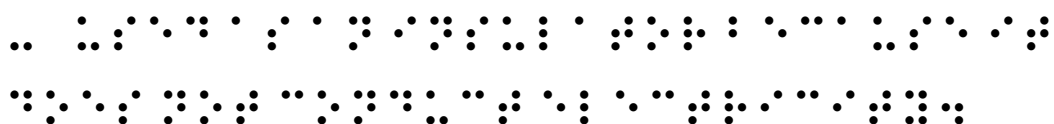
NB: Diamond is used here because it is the hardest known substance.

Diamond is also used in the manufacture of high-speed cutting tools and in the production of synthetic diamonds for industrial and jewelry purposes.

- Used as valuables such as jewelry and ornaments because it is transparent and glitters when polished.

Diamond jewelry is highly valued for its brilliance and durability. It is also used in the manufacture of high-pressure cells for scientific research.

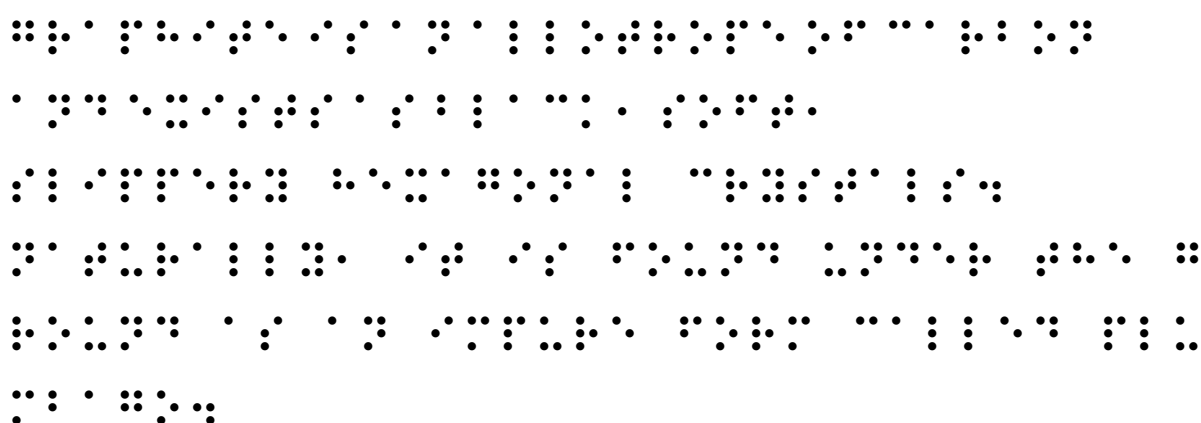
- Used as an insulator because it does not conduct electricity.



Graphite



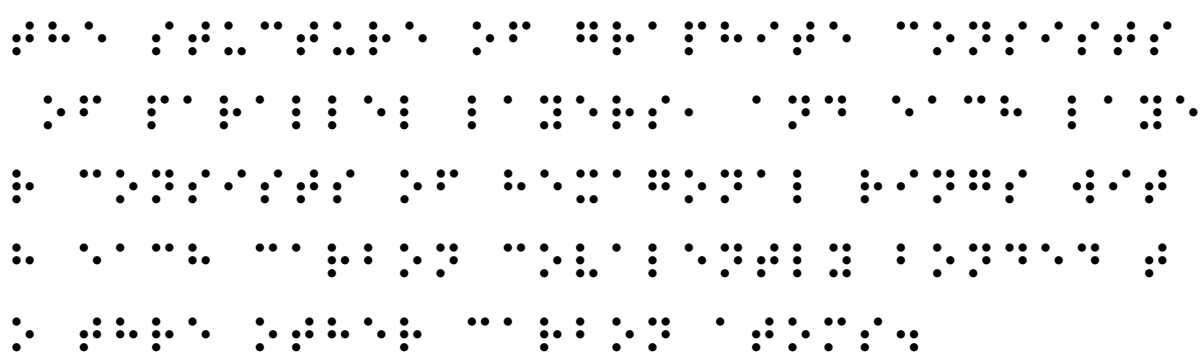
Graphite is an allotrope of carbon and exists as black, soft, slippery hexagonal crystals. Naturally, it is found under the ground as an impure form called plumbago.



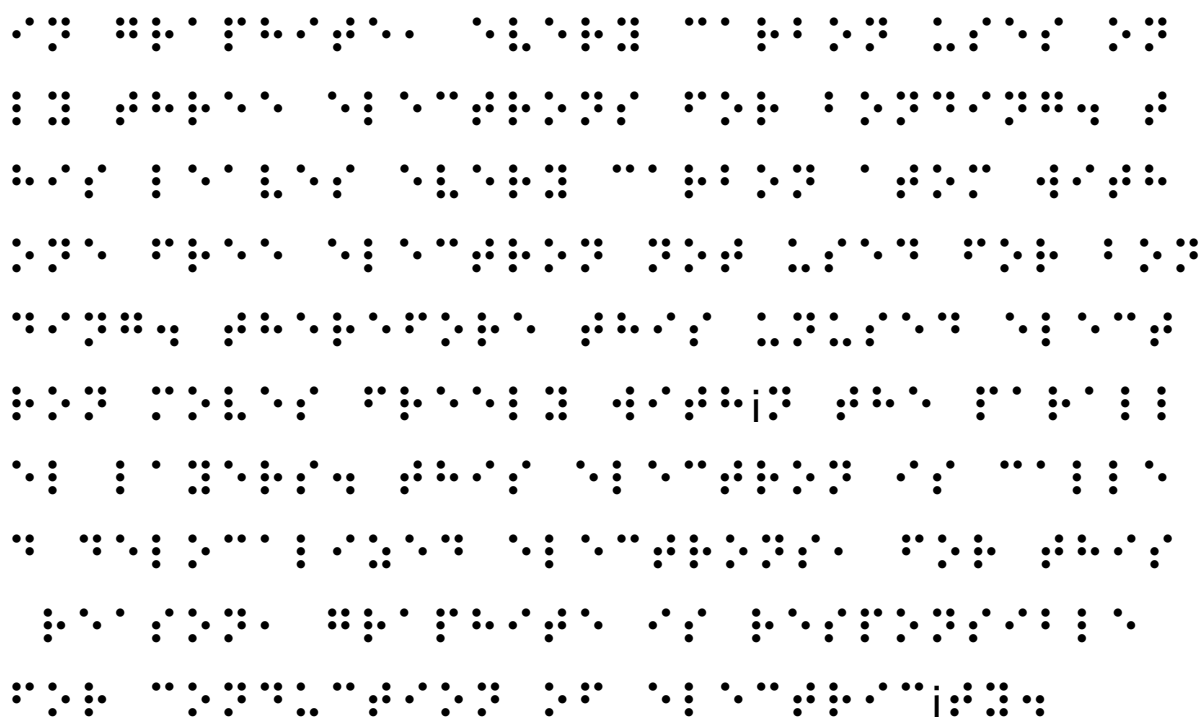
Structure of graphite



The structure of graphite consists of parallel layers, and each layer consists of hexagonal rings with each carbon covalently bonded to three other carbon atoms.



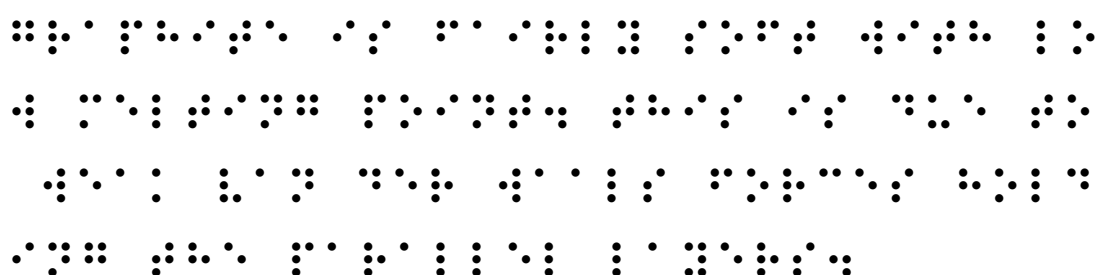
In graphite, every carbon uses only three electrons for bonding. This leaves every carbon atom with one free electron not used for bonding. Therefore, this unused electron moves freely within the parallel layers. This electron is called delocalized electron; for this reason, graphite is responsible for conduction of electricity.



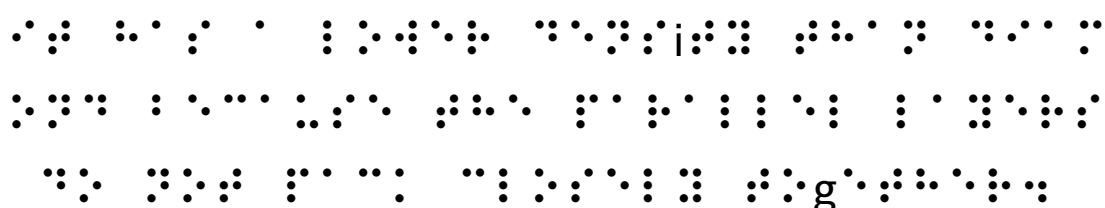
Properties of graphite



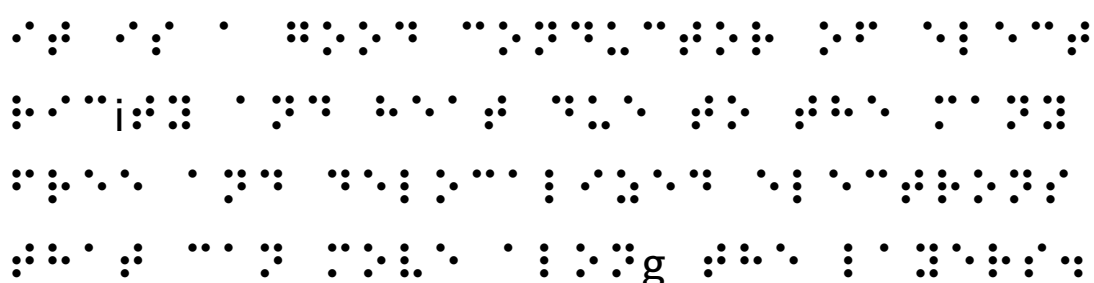
- Graphite is fairly soft and has a low melting point. This is due to the weak van der Waals forces holding the parallel layers.



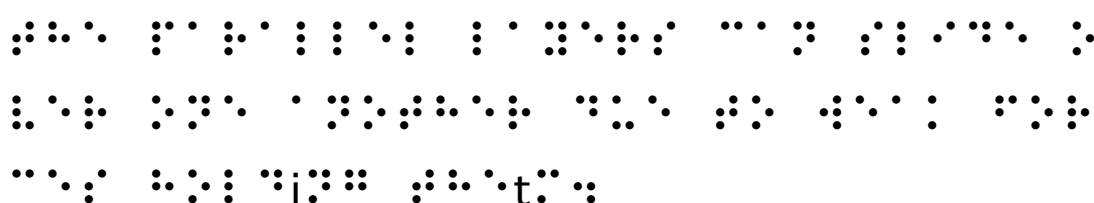
- It has a lower density than diamond because the parallel layers do not pack closely together.



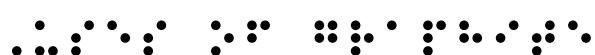
- It is a good conductor of electricity and heat due to the many free and delocalized electrons that can move along the layers.



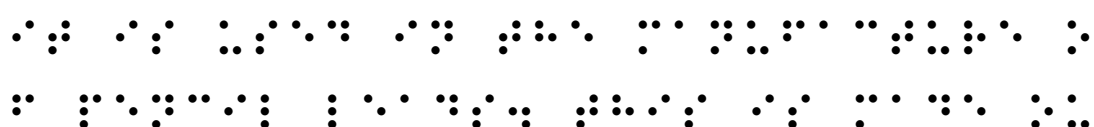
- The parallel layers can slide over one another due to the weak forces holding them.



Uses of Graphite



- It is used in the manufacture of pencil leads. This is made out of graphite and clay because it is black and opaque.



Graphite is a form of carbon in which the carbon atoms are arranged in layers. Each layer is a hexagonal lattice of carbon atoms. The layers are held together by weak van der Waals forces, which allows them to slide over each other easily.

- It is used as a lubricant for small bearings like those in dynamos and vacuum cleaner motors which require little but regular lubrication. This is because graphite is slippery and soft.

Graphite is used as a lubricant because of its layered structure. The layers of carbon atoms are held together by weak van der Waals forces, which allows them to slide over each other easily. This makes graphite a good lubricant for small bearings like those in dynamos and vacuum cleaner motors.

- It is used in the manufacture of electrodes because graphite is a good conductor of electricity due to the presence of delocalized electrons.

Graphite is used in the manufacture of electrodes because it is a good conductor of electricity. This is due to the presence of delocalized electrons in the structure of graphite. The layers of carbon atoms are held together by weak van der Waals forces, which allows the electrons to move freely between the layers.

- It is used as a protective coating on iron to prevent it from rusting.

Graphite is used as a protective coating on iron to prevent it from rusting. This is because graphite is a good conductor of electricity and it forms a protective layer on the surface of the iron, preventing it from reacting with oxygen and water.

Carbon is a non-metallic element. It is found in the earth's crust in the form of graphite and diamond. It is also found in the form of coal, coke, and charcoal.

- **Coke:** Formed by heating coal out of contact with air. Used as fuel in boilers, ovens, etc.

Carbon is a non-metallic element. It is found in the earth's crust in the form of graphite and diamond. It is also found in the form of coal, coke, and charcoal.

Compounds of Carbon

Carbon forms a large number of compounds.

Carbon Dioxide

Carbon dioxide is a colourless and odourless gas.

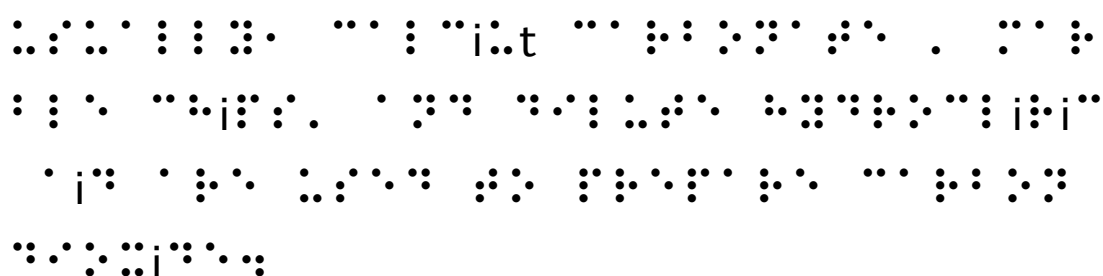
Laboratory preparation of carbon dioxide

Carbon dioxide is prepared in the laboratory by reacting a carbonate with dilute acid.

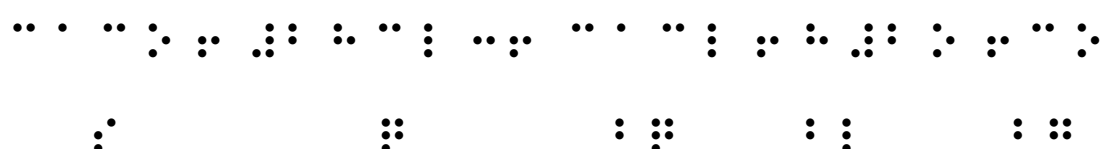
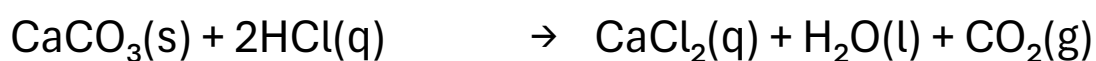
In the laboratory, carbon dioxide is prepared by reacting a carbonate with dilute acid.

Carbon dioxide is prepared in the laboratory by reacting a carbonate with dilute acid.

Usually, calcium carbonate (marble chips) and dilute hydrochloric acid are used to prepare carbon dioxide.



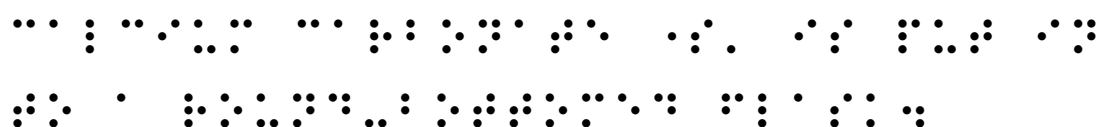
Equation



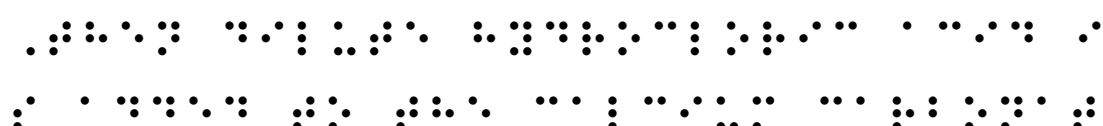
Procedure

1. Preparation of carbon dioxide gas

Calcium carbonate (s) is put into a round-bottomed flask.



Then dilute hydrochloric acid is added to the calcium carbonate. Immediately, carbon dioxide gas is evolved, seen as colourless bubbles.



Chemical Test for Carbon Dioxide

Carbon dioxide is detected by passing it through lime water.

Reagent: Lime water (calcium hydroxide solution)

Chemical equation for the reaction of carbon dioxide with lime water:

$$\text{CO}_2 + \text{Ca(OH)}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O}$$

Procedure:

1. Prepare lime water.

When carbon dioxide is passed through lime water, the lime water turns milky.

The milky solution is due to the formation of calcium carbonate, which is an insoluble salt.

This reaction confirms the presence of carbon dioxide.

Chemical equation for the reaction of carbon dioxide with lime water:

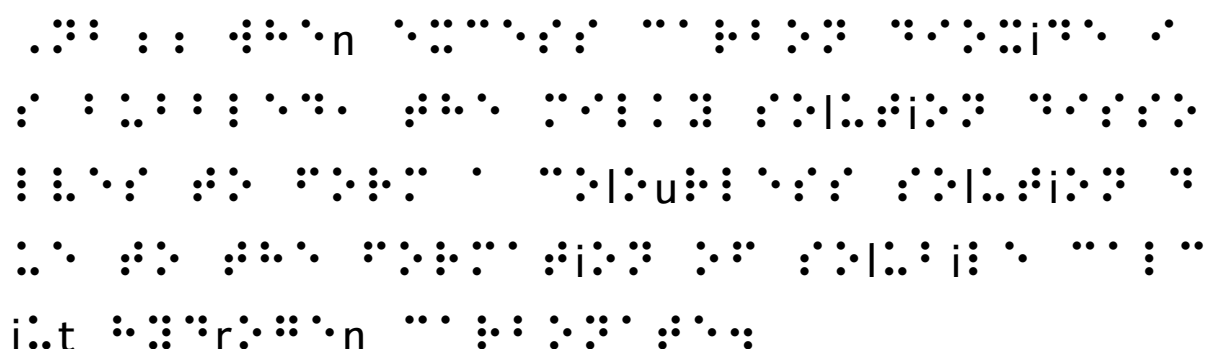
$$\text{CO}_2 + \text{Ca(OH)}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O}$$

The milky solution is due to the formation of calcium carbonate, which is an insoluble salt.

Chemical equation for the reaction of carbon dioxide with lime water:

$$\text{CO}_2 + \text{Ca(OH)}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O}$$

NB// When excess carbon dioxide is bubbled, the milky solution dissolves to form a colourless solution due to the formation of soluble calcium hydrogen carbonate.



Physical properties of carbon dioxide

Carbon dioxide is a colourless, odourless gas. It is heavier than air and does not support combustion.

Chemical properties of carbon dioxide

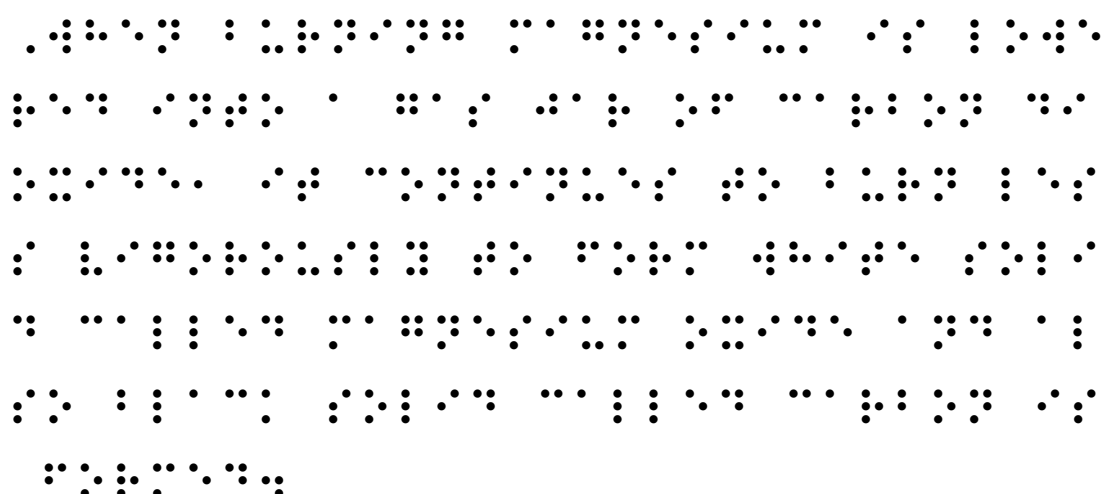
Carbon dioxide reacts with water to form carbonic acid. It also reacts with bases to form carbonates and bicarbonates.

(a) Burning magnesium

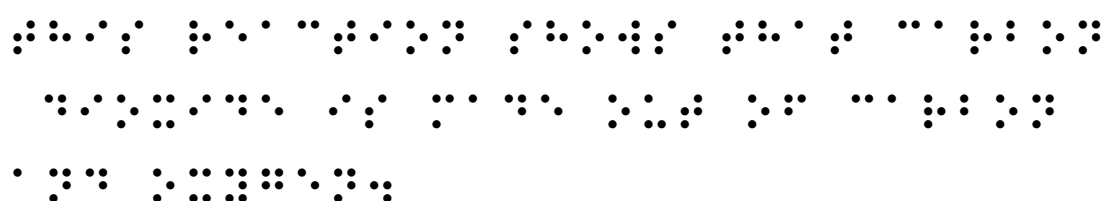


When burning magnesium is lowered into a gas jar of carbon dioxide, it continues to burn less vigorously to form white solid called magnesium oxide and also black solid

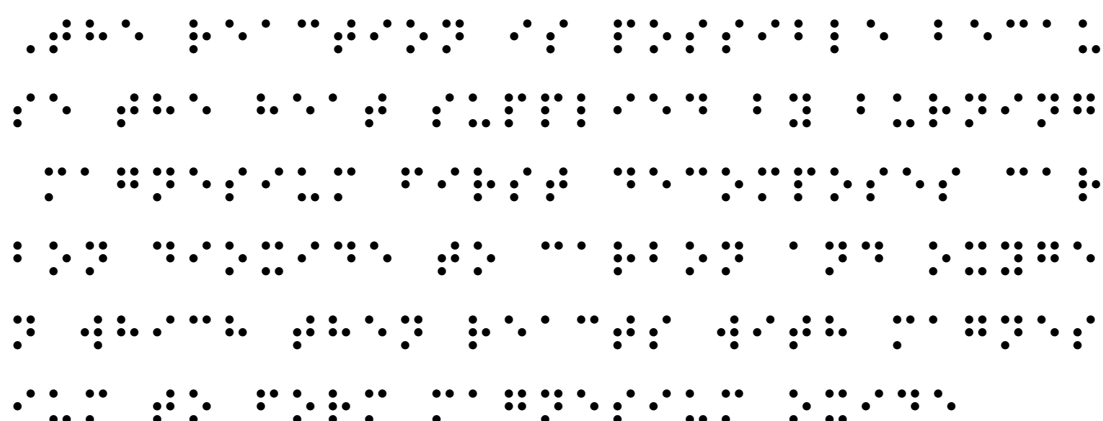
called carbon is formed.



This reaction shows that carbon dioxide is made out of carbon and oxygen.



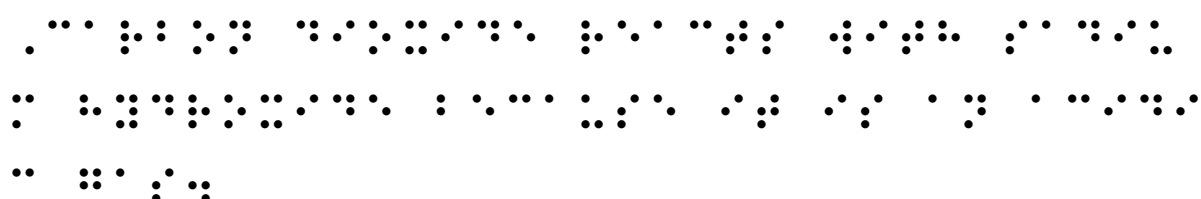
The reaction is possible because the heat supplied by burning magnesium first decomposes carbon dioxide to carbon and oxygen which then reacts with magnesium to form magnesium oxide.



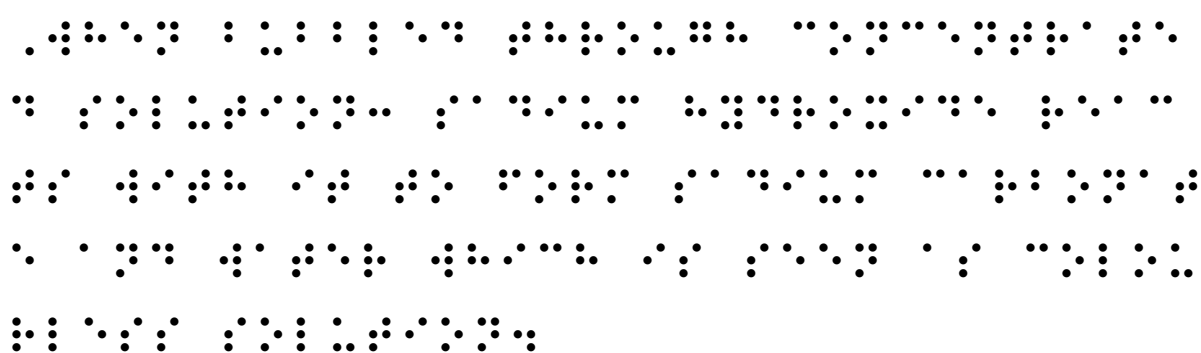
(b) Sodium hydroxide



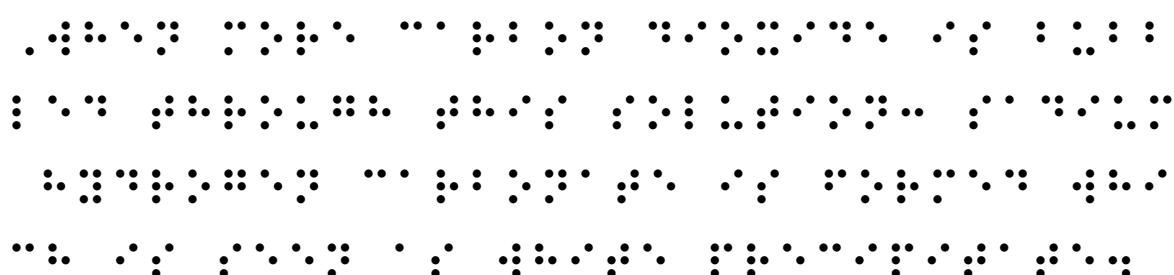
Carbon dioxide reacts with sodium hydroxide because it is an acidic gas.



When bubbled through concentrated solution, sodium hydroxide reacts with it to form sodium carbonate and water which is seen as colourless solution.



When more carbon dioxide is bubbled through this solution, sodium hydrogen carbonate is formed which is seen as white precipitate.



NB. In nature carbon dioxide can be produced by the following processes.

Carbon dioxide is a gas that is produced by the combustion of organic matter, petroleum products, and the respiration of animals and plants. It is a greenhouse gas that contributes to global warming.

- Combustion of burning organic matter, petroleum products.

Carbon dioxide is a gas that is produced by the combustion of organic matter, petroleum products, and the respiration of animals and plants. It is a greenhouse gas that contributes to global warming.

- Respiration. This takes place in animal and plant tissues.

Carbon dioxide is a gas that is produced by the combustion of organic matter, petroleum products, and the respiration of animals and plants. It is a greenhouse gas that contributes to global warming.

2. Process that consumes carbon dioxide is photosynthesis.

Photosynthesis is the process by which plants and other organisms use sunlight to synthesize foods from carbon dioxide and water. Photosynthesis in plants generally involves the green pigment chlorophyll and converts carbon dioxide and water into glucose and oxygen.

3. In nature there must be a balance between natural processes that produce carbon dioxide and natural processes which reduce the amount of carbon dioxide. An imbalance leads to increased production of carbon dioxide in the atmosphere. This leads to greenhouse effect which causes global warming.

Carbon dioxide is a gas that is produced by the combustion of organic matter, petroleum products, and the respiration of animals and plants. It is a greenhouse gas that contributes to global warming.

Carbon dioxide is a colourless, odourless gas. It is heavier than air and does not support combustion. It is used in fire extinguishers, carbonated drinks, and as a refrigerant. It is also a natural part of the Earth's atmosphere.

Uses of carbon dioxide

Carbon dioxide has several uses in industry and everyday life.

- It is used in fire extinguisher because it does not support burning.

Carbon dioxide is used in fire extinguishers because it is heavier than air and does not support combustion. It is also used in the manufacture of carbonated drinks.

- It is used in the manufacture of aerated drinks such as lemonade, beer, soda because it gives these drinks their flavour and tastes.

Carbon dioxide is used in the manufacture of aerated drinks because it gives these drinks their flavour and tastes. It is also used in the manufacture of carbonated drinks.

- It is used in refrigerators as dry ice (solid carbon dioxide).

Carbon dioxide is used in refrigerators as dry ice (solid carbon dioxide). It is also used in the manufacture of carbonated drinks.

INDUSTRIAL PROCESSES

Importance of teaching industrial processes in relation to innovation

Teaching industrial processes inspires learners to think creatively and innovatively by showing how scientific knowledge is transformed into practical solutions that meet human needs.

[illegible]

Learners understand that chemistry is not only theoretical but a powerful tool for creating new products and improving existing ones.

[illegible]

Industrial processes encourage learners to identify problems and design solutions.

By studying how industries optimize raw materials, energy use, and reaction conditions, learners develop the ability to improve efficiency and reduce waste.

Teaching industrial processes prepares learners to become future innovators and entrepreneurs.

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Industrial processes encourage learners to identify problems and design solutions.

The Solvay Process

$\text{NaCl} + \text{NH}_3 + \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{NaHCO}_3 + \text{NH}_4\text{Cl}$

The Contact Process (for sulfuric acid)

$\text{S} + \text{O}_2 \rightarrow \text{SO}_2$
 $\text{SO}_2 + \text{O}_2 \rightarrow \text{SO}_3$
 $\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4$

The Haber Process (for ammonia)

$\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$

The Electrolysis of Brine (for chlorine and sodium hydroxide)

$2\text{NaCl} + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2 + \text{Cl}_2$

The Blast Furnace Process (for iron)

$\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$

The Distillation of Crude Oil (for petroleum products)

$\text{C}_{10}\text{H}_{22} \rightarrow \text{C}_8\text{H}_{18} + \text{C}_2\text{H}_6$
 $\text{C}_{10}\text{H}_{22} \rightarrow \text{C}_6\text{H}_{14} + \text{C}_4\text{H}_{10}$
 $\text{C}_{10}\text{H}_{22} \rightarrow \text{C}_5\text{H}_{12} + \text{C}_5\text{H}_{10}$

The Linde Process (for liquefying gases like oxygen and nitrogen)

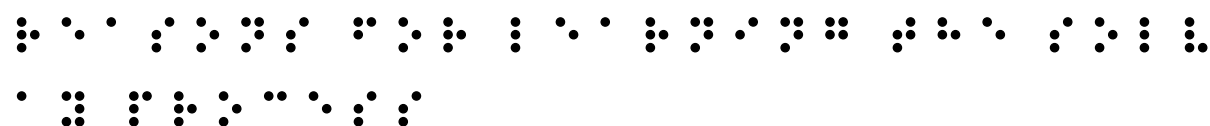
$\text{N}_2 + \text{O}_2 \rightarrow \text{N}_2\text{O}$

Cement

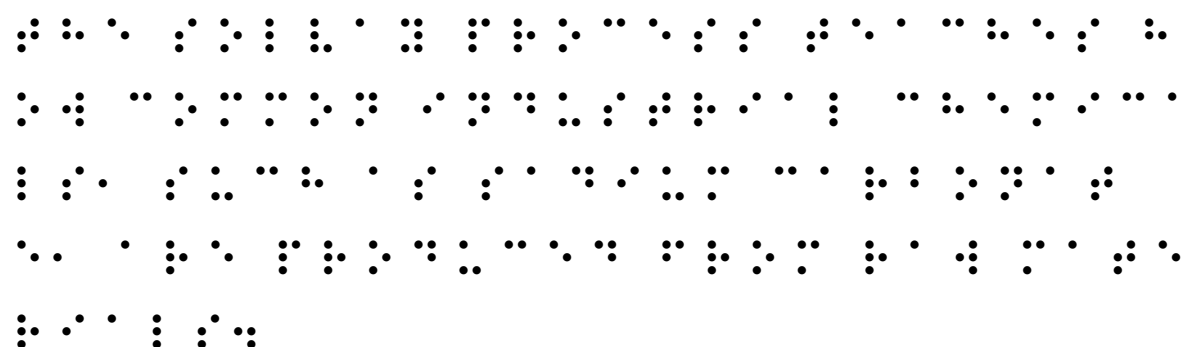
Solvay Process



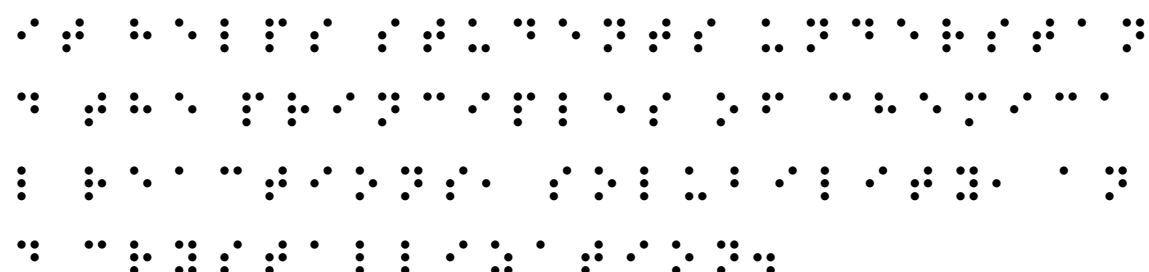
1. Reasons for Learning the Solvay Process



The Solvay process teaches how common industrial chemicals, such as sodium carbonate, are produced from raw materials.



It helps students understand the principles of chemical reactions, solubility, and crystallization.



It demonstrates large-scale chemical production and how laboratory principles are applied in industries.

Ammonia gas is passed through the brine until it becomes saturated. The solution is then cooled to form a precipitate of sodium ammonium carbonate. This is then heated to produce sodium carbonate and ammonia gas, which is recycled.

Step-by-step procedure of the Solvay process

1. Preparation of ammonia-saturated brine

Step 1: Preparation of ammonia-saturated brine

Concentrated sodium chloride solution is prepared and purified to remove impurities.

Ammonia gas is passed through the brine until it becomes saturated.

The solution is then cooled to form a precipitate of sodium ammonium carbonate. This is then heated to produce sodium carbonate and ammonia gas, which is recycled.

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The solution is then cooled to form a precipitate of sodium ammonium carbonate. This is then heated to produce sodium carbonate and ammonia gas, which is recycled.

Step 2: Production of carbon dioxide

Limestone is heated strongly in a lime kiln.

Limestone is heated strongly in a lime kiln.

Carbon dioxide gas is produced and collected for use in the process.

Carbon dioxide gas is produced and collected for use in the process.

Step 3: Formation of sodium hydrogen carbonate

Carbon dioxide is passed through the ammonia-saturated brine.

Carbon dioxide is passed through the ammonia-saturated brine.

Sodium hydrogen carbonate forms and precipitates out.

Sodium hydrogen carbonate forms and precipitates out.

Step 4: Filtration of sodium hydrogen carbonate

The mixture is filtered to separate the solid sodium hydrogen carbonate from the liquid solution.

The solid sodium hydrogen carbonate is separated by filtration.

The solid sodium hydrogen carbonate is separated by filtration. The liquid solution is then evaporated to dryness to obtain the solid sodium hydrogen carbonate.

Step 5: Conversion to sodium carbonate

The solid sodium hydrogen carbonate is heated to form sodium carbonate and water vapor.

Sodium hydrogen carbonate is heated to form sodium carbonate.

The solid sodium hydrogen carbonate is heated to form sodium carbonate and water vapor. The water vapor is condensed and collected as liquid water.

Step 6: Recovery of ammonia

The ammonia gas is recovered and reused in the process.

Ammonia is recovered and reused in the process.

The ammonia gas is recovered and reused in the process. The ammonia gas is recovered by passing the gas mixture through a solution of sulfuric acid, which reacts with the ammonia to form ammonium sulfate. The ammonium sulfate is then heated to release the ammonia gas, which is then dried and reused in the process.

Step 7: Collection of sodium carbonate

The solution is then evaporated to collect sodium carbonate. The solid is then dried and packed for use.

Sodium carbonate is dried and packed for use.

The solid is then dried and packed for use.

Importance for the Future

Learning the Solvay process allows industries to produce essential chemicals efficiently, reducing costs and meeting demand.

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The Solvay process is a chemical process used to produce sodium carbonate. It involves the reaction of sodium chloride, ammonia, and carbon dioxide to form sodium bicarbonate, which is then heated to produce sodium carbonate. The process is efficient and produces a high-purity product.

It promotes innovation in chemical industries by understanding how processes can be optimized.

The Solvay process is a chemical process used to produce sodium carbonate. It involves the reaction of sodium chloride, ammonia, and carbon dioxide to form sodium bicarbonate, which is then heated to produce sodium carbonate. The process is efficient and produces a high-purity product.

Environmental Impact

The Solvay process generates waste products like calcium chloride, which can affect soil and water if not managed properly.

Brine (sodium chloride solution) is first purified to remove calcium and magnesium impurities.

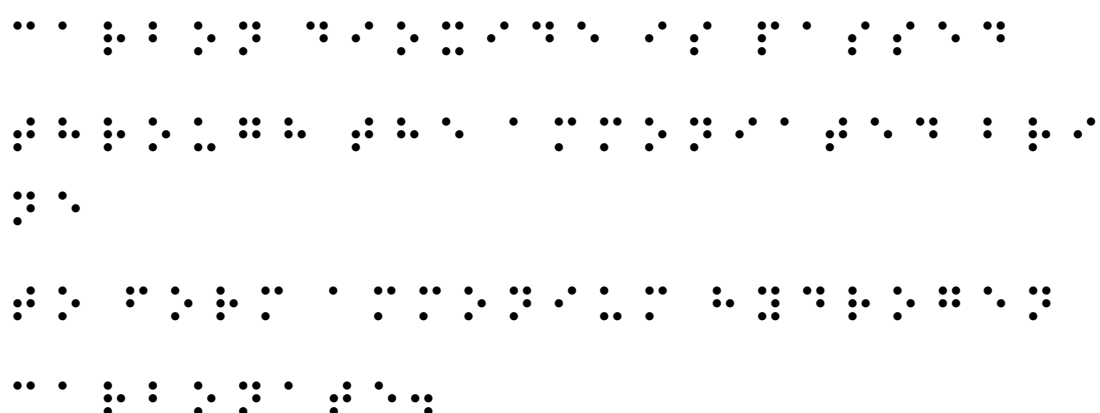
[illegible]

The purified brine is saturated with ammonia gas.

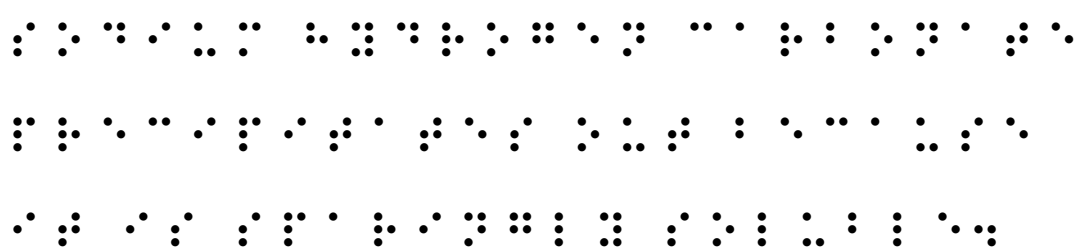




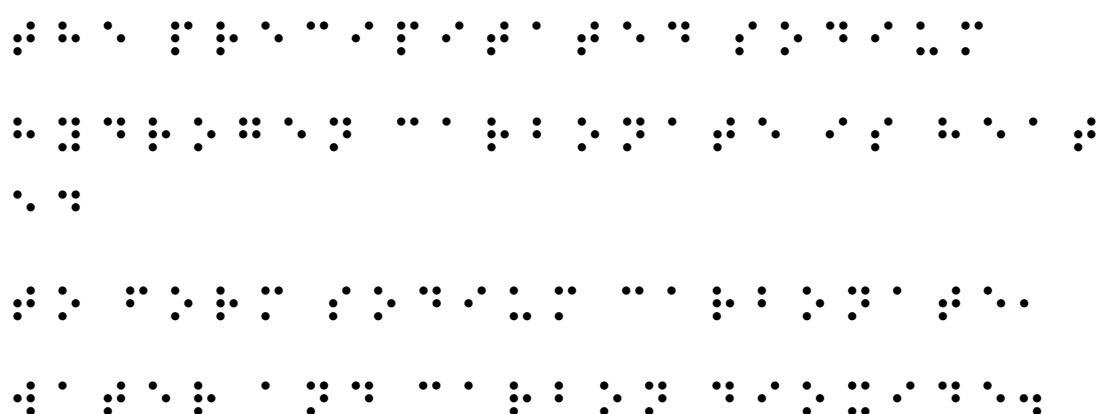
Carbon dioxide is passed through the ammoniated brine to form ammonium hydrogen carbonate.



Sodium hydrogen carbonate precipitates out because it is sparingly soluble.



The precipitated sodium hydrogen carbonate is heated to form sodium carbonate, water and carbon dioxide.



Sulfur dioxide is a colorless, odorless gas that is heavier than air. It is produced by the combustion of sulfur or the roasting of sulfide ores. It is a major air pollutant and a precursor to acid rain.

Step-by-step procedure of the Contact Process

The Contact Process is used to produce sulfuric acid. It involves the oxidation of sulfur dioxide to sulfur trioxide, which is then dissolved in water to form sulfuric acid.

Step 1: Sulfur Combustion

Sulfur (S) is burned in air to produce sulfur dioxide (SO₂).

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Sulfur + Oxygen → Sulfur dioxide

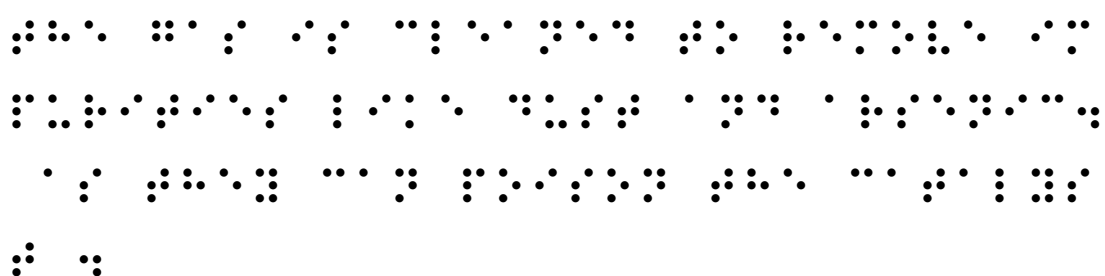
Sulfur + Oxygen → Sulfur dioxide

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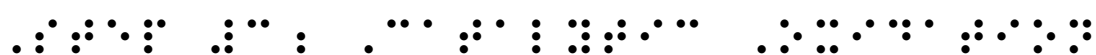
Step 2: Purification of Sulfur Dioxide

Sulfur dioxide is purified by passing it through a series of washers to remove impurities. The purified sulfur dioxide is then used in the next step of the process.

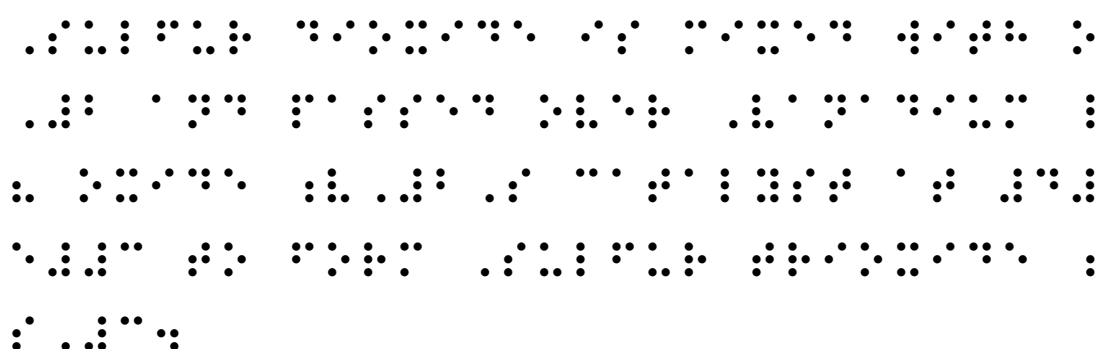
The gas is cleaned to remove impurities like dust and arsenic, as they can poison the catalyst.



Step 3: Catalytic Oxidation



Sulfur dioxide is mixed with oxygen and passed over vanadium(V) oxide (V_2O_5) catalyst at $\sim 450^\circ\text{C}$ to form sulfur trioxide (SO_3).



Step 4: Absorption in Concentrated Sulfuric Acid



The sulfur trioxide is absorbed in concentrated H_2SO_4 to form oleum ($\text{H}_2\text{S}_2\text{O}_7$).

Step 4: Concentration of Sulfuric Acid
Oleum is a mixture of sulfur trioxide and sulfuric acid. It is a highly corrosive liquid. It is used in the production of sulfuric acid. It is also used in the production of other chemicals. It is a key component in many industrial processes.

Step 5: Dilution to Form Sulfuric Acid

Oleum is carefully diluted with water to form concentrated sulfuric acid. This process is exothermic, meaning it releases heat. It must be done carefully to avoid splashing or boiling.

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Oleum + Water → Sulfuric acid

Oleum is a mixture of sulfur trioxide and sulfuric acid. It is a highly corrosive liquid. It is used in the production of sulfuric acid. It is also used in the production of other chemicals. It is a key component in many industrial processes.

Uses of Sulfuric Acid

Sulfuric acid is one of the most important chemicals in industries. Some uses include:

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Manufacture of fertilizers such as ammonium sulfate.

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Manufacture of detergents and cleaning agents.

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Manufacture of chemicals like hydrochloric acid, nitric acid, and dyes.

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Manufacture of batteries.

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Used in petroleum refining.

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Environmental Impact

- Production of sulfuric acid can release sulfur dioxide gas, which contributes to acid rain.

Improper disposal of waste can lead to soil and water pollution. Safety measures are essential to protect workers.

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Project Idea

Reaction of Sulfuric Acid with Metals

Objective: Investigate the reaction of sulfuric acid with metals safely to produce hydrogen gas.

Materials: Zinc granules, dilute sulfuric acid, test tube, delivery tube, gas jar.

Procedure: Add zinc granules to a test tube containing dilute sulfuric acid. Invert a gas jar over the mouth of the test tube. Bubbles of hydrogen gas will be observed.

Chemical equation: $\text{Zn} + \text{H}_2\text{SO}_4 \rightarrow \text{ZnSO}_4 + \text{H}_2$

١. ٢. ٣. ٤. ٥. ٦. ٧. ٨. ٩. ١٠. ١١. ١٢. ١٣. ١٤. ١٥. ١٦. ١٧. ١٨. ١٩. ٢٠. ٢١. ٢٢. ٢٣. ٢٤. ٢٥. ٢٦. ٢٧. ٢٨. ٢٩. ٣٠. ٣١. ٣٢. ٣٣. ٣٤. ٣٥. ٣٦. ٣٧. ٣٨. ٣٩. ٤٠. ٤١. ٤٢. ٤٣. ٤٤. ٤٥. ٤٦. ٤٧. ٤٨. ٤٩. ٥٠. ٥١. ٥٢. ٥٣. ٥٤. ٥٥. ٥٦. ٥٧. ٥٨. ٥٩. ٦٠. ٦١. ٦٢. ٦٣. ٦٤. ٦٥. ٦٦. ٦٧. ٦٨. ٦٩. ٧٠. ٧١. ٧٢. ٧٣. ٧٤. ٧٥. ٧٦. ٧٧. ٧٨. ٧٩. ٨٠. ٨١. ٨٢. ٨٣. ٨٤. ٨٥. ٨٦. ٨٧. ٨٨. ٨٩. ٩٠. ٩١. ٩٢. ٩٣. ٩٤. ٩٥. ٩٦. ٩٧. ٩٨. ٩٩. ١٠٠.

Procedure:

1. Add zinc to dilute sulfuric acid in a test tube.
2. Collect the hydrogen gas produced in a gas jar using a delivery tube.
3. Observe and record the reaction using tactile indicators (bubbles).

[illegible]

Project Title: “Making Sodium Carbonate (Baking Soda) from Household Materials”

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Objective: To understand the principles of the Solvay process (reaction of ammonia, carbon dioxide, and salt solution) by producing a small-scale safe version of sodium carbonate.

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Materials

Materials

- Table salt (NaCl)

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- Ammonia solution (diluted, safe concentration)

Ammonia solution (diluted, safe concentration)

- Baking soda (NaHCO_3) – as a comparison

THESEQUESTERED

- Water

- Beaker or jar

- Stirring rod

- Gloves

Procedure: Dissolve salt in water – students can feel the salt dissolving by stirring.

١٠٢٣٤٥٦٧٨٩١٠١١١٢١٣١٤١٥١٦١٧١٨١٩٢٠
٢١٢٢٢٣٢٤٢٥٢٦٢٧٢٨٢٩٣٠٣١٣٢٣٣٣٤٣٥٣٦٣٧٣٨٣٩٤٠
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Add ammonia solution – blind students can smell the ammonia (ensure ventilation).

[illegible]

Bubble carbon dioxide (from baking soda + vinegar reaction) through the solution – both blind and sighted students can feel bubbles in the solution.

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840.

Observe the formation of solid sodium bicarbonate – students can touch and feel the precipitate forming.

[illegible]

Filter or collect the solid – tactile learning of solid vs liquid.

[illegible]

Compare the product with store-bought baking soda using touch and smell.

[illegible]

Learning Outcomes: Understand gas-liquid-solid reactions.

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840.

Learn the basic principles of the Solvay process (reaction of CO_2 , NH_3 , and NaCl to form NaHCO_3).

[illegible]

Learn how industrial processes are scaled up safely.

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Hands-on tactile and olfactory experience for blind students.

[illegible]

Fun Element: Students can measure the volume of bubbles produced.

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Students can feel and compare textures of the precipitate.

The Braille representation of the sentence "The cat sat on the mat." consists of two rows of six cells each. The first row contains the words "The", "cat", "sat", "on", "the", and "mat.". The second row contains the words "The", "dog", "was", "in", "the", and "house.".

Safe smell test of ammonia and baking soda.

[illegible]

Ostwald Process of Nitric Acid




























The Ostwald process is an industrial method used to produce nitric acid from ammonia gas. It involves the catalytic oxidation of ammonia to form nitrogen oxides, which are then absorbed in water to form nitric acid. This process is essential for producing chemicals on a large scale.

[illegible]

Why it is necessary:

The Ostwald process is important because it produces nitric acid, a key raw material in the manufacture of fertilizers, explosives, dyes, and other industrial chemicals. Understanding this process helps students and industry workers learn how chemical reactions are scaled up safely.

Ammonia gas (NH_3) is oxidized using a platinum-rhodium catalyst at high temperature to produce nitric oxide (NO). The reaction is exothermic and occurs in the gas phase. The catalyst is a fine mesh of platinum and rhodium. The reaction is carried out in a reactor where the ammonia gas and oxygen are mixed and then passed over the catalyst. The temperature is maintained at around 800°C. The products are nitric oxide and water vapor. The nitric oxide is then further oxidized to nitrogen dioxide in the next step.

Procedure:

Step 1: Ammonia gas (NH_3) is oxidized using a platinum-rhodium catalyst at high temperature to produce nitric oxide (NO).

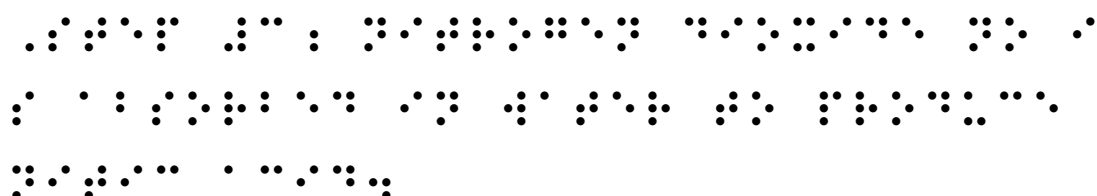
Step 1: Ammonia gas (NH_3) is oxidized using a platinum-rhodium catalyst at high temperature to produce nitric oxide (NO).

The reaction is exothermic and occurs in the gas phase. The catalyst is a fine mesh of platinum and rhodium. The reaction is carried out in a reactor where the ammonia gas and oxygen are mixed and then passed over the catalyst. The temperature is maintained at around 800°C. The products are nitric oxide and water vapor. The nitric oxide is then further oxidized to nitrogen dioxide in the next step.

Step 2: Nitric oxide (NO) is oxidized by oxygen (O_2) to form nitrogen dioxide (NO_2).

The reaction is exothermic and occurs in the gas phase. The catalyst is a fine mesh of platinum and rhodium. The reaction is carried out in a reactor where the nitric oxide and oxygen are mixed and then passed over the catalyst. The temperature is maintained at around 800°C. The products are nitrogen dioxide and water vapor.

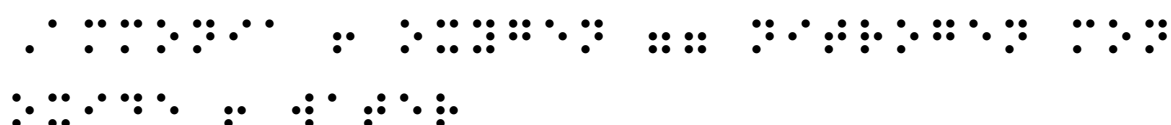
Step 3: Nitrogen dioxide (NO₂) is absorbed in water to produce nitric acid (HNO₃).



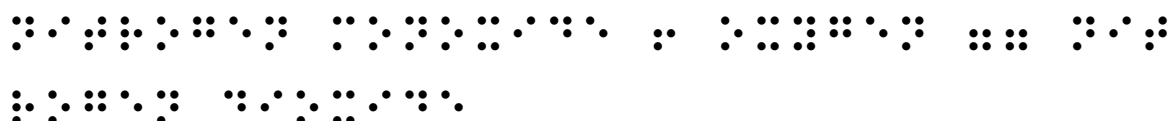
Equations



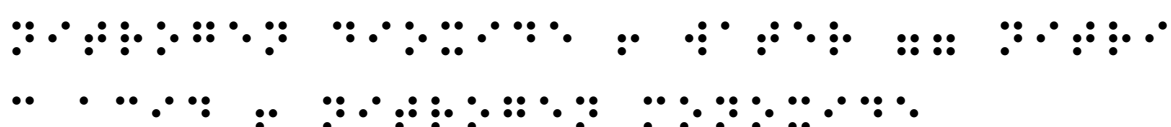
Ammonia + Oxygen → Nitrogen monoxide + Water



Nitrogen monoxide + Oxygen → Nitrogen dioxide



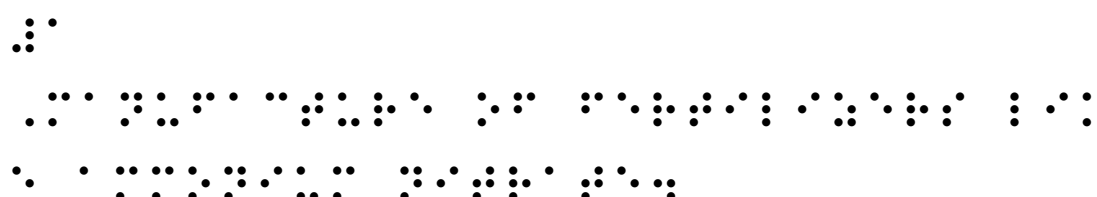
Nitrogen dioxide + Water → Nitric acid + Nitrogen monoxide



Uses of Nitric Acid:



1. Manufacture of fertilizers like ammonium nitrate.



2. Production of explosives such as TNT.

[illegible]

3. Manufacture of dyes and industrial chemicals.

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The Haber Process: History, Mechanism, Importance, and Fascinating Facts

The Haber process is a chemical reaction that combines nitrogen and hydrogen to produce ammonia. It is a key industrial process for the production of fertilizers and explosives.

1. History of the Haber Process

The Haber process was developed by the German chemist Fritz Haber in 1908. It was the first time that nitrogen was fixed from the atmosphere.

The Haber Process was developed in the early 20th century by the German chemist Fritz Haber.

The process involves the reaction of nitrogen gas with hydrogen gas under high pressure and temperature to produce ammonia. The reaction is exothermic, meaning it releases heat.

Before its discovery, the world relied heavily on natural sources of nitrogen compounds such as guano and saltpeter, which were rapidly being depleted.

The Haber process revolutionized the production of nitrogen compounds, allowing for the mass production of fertilizers and explosives. It was a major breakthrough in chemistry and industry.

Chemical equation for the Haber process:

$$\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$$

Steps Involved in the Haber Process

The Haber process involves the synthesis of ammonia from nitrogen and hydrogen gases under specific conditions:

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Chemical equation for the Haber process:

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1. Purification of gases

Nitrogen is obtained from air, while hydrogen is usually obtained from natural gas or water.

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Chemical equation for the Haber process:

$$\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$$

2. Compression of gases

N_2 and H_2 are mixed in a 1:3 ratio and compressed to high pressure (about 200 atmospheres).

Nitrogen and hydrogen are mixed in a 1:3 ratio and compressed to high pressure (about 200 atmospheres).

N_2 and H_2 are mixed in a 1:3 ratio and compressed to high pressure (about 200 atmospheres).

3. Heating

N_2 and H_2 are mixed in a 1:3 ratio and compressed to high pressure (about 200 atmospheres).

The gas mixture is heated to a temperature of approximately 450°C.

N_2 and H_2 are mixed in a 1:3 ratio and compressed to high pressure (about 200 atmospheres).

4. Use of a catalyst

N_2 and H_2 are mixed in a 1:3 ratio and compressed to high pressure (about 200 atmospheres).

An iron catalyst, often promoted with potassium oxide or aluminum oxide, is used to increase the reaction rate.

N_2 and H_2 are mixed in a 1:3 ratio and compressed to high pressure (about 200 atmospheres).

urea.

Urea is a chemical compound with the molecular formula $\text{CH}_2\text{N}_2\text{O}$. It is a colorless, odorless solid that is highly soluble in water. Urea is produced industrially from ammonia and carbon dioxide through the urea cycle. It is widely used in agriculture as a nitrogen fertilizer and in various industrial processes, including the production of plastics, pharmaceuticals, and food additives.

It is estimated that nearly half of the world's population depends on food grown using fertilizers produced via the Haber Process.

The Haber Process is a chemical process for the synthesis of ammonia from nitrogen and hydrogen gases. It involves the reaction of these gases under high pressure and temperature in the presence of an iron catalyst. The resulting ammonia is then used in various applications, including the production of fertilizers, explosives, and other chemical products.

Without it, global food shortages and famine would be widespread.

The Haber Process is a critical component of modern agriculture. It has enabled the production of large quantities of ammonia, which is essential for the synthesis of nitrogen-based fertilizers. These fertilizers are used to enhance the growth and yield of crops, ensuring food security for a growing population.

Additionally, ammonia is used in the production of explosives, pharmaceuticals, cleaning agents, and refrigeration systems.

Ammonia is a versatile chemical compound with a wide range of applications. It is used in the production of various chemicals, including explosives, pharmaceuticals, and cleaning agents. It is also used in refrigeration systems and as a raw material in the chemical industry.

• The Haber process is a chemical reaction that combines nitrogen and hydrogen to produce ammonia. It is named after its inventor, Fritz Haber.

Fun and Interesting Facts About the Haber Process

• The Haber process is a chemical reaction that combines nitrogen and hydrogen to produce ammonia. It is named after its inventor, Fritz Haber.

- Around 78% of the air is nitrogen, yet plants cannot use it directly — the Haber Process makes it usable.

• The Haber process is a chemical reaction that combines nitrogen and hydrogen to produce ammonia. It is named after its inventor, Fritz Haber.

- The process is considered one of the most important chemical reactions ever discovered.

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- It consumes about 1–2% of the world's total energy supply.

• The Haber process is a chemical reaction that combines nitrogen and hydrogen to produce ammonia. It is named after its inventor, Fritz Haber.

- Fritz Haber's invention helped save billions of lives but was also used in warfare, making his legacy controversial.

• The Haber process is a chemical reaction that combines nitrogen and hydrogen to produce ammonia. It is named after its inventor, Fritz Haber.

Ammonia is a chemical compound with the molecular formula NH_3 . It is a colorless, pungent gas at room temperature. Ammonia is produced industrially by the Haber process, which involves the reaction of nitrogen gas (N_2) and hydrogen gas (H_2) under high pressure and temperature in the presence of an iron catalyst.

- Ammonia produced by the Haber Process is one of the most manufactured chemicals in the world.

Ammonia is used in a wide range of applications, including the production of fertilizers, explosives, and pharmaceuticals. It is also used in the food industry as a preservative and in the textile industry for the production of synthetic fibers. Ammonia is a key component in the production of many other chemicals, including nitric acid, urea, and ammonium salts.

SCENARIOS THAT SHOW SIGNIFICANCE OF THE HABER PROCESS

The Haber process has revolutionized the production of ammonia, which is a key component in many fertilizers. This has led to a significant increase in agricultural productivity, particularly in the production of staple crops like wheat and corn.

1. Agriculture & Fertilizers

- Fertilizers are essential for modern agriculture, and ammonia is a key component in many fertilizers.

Imagine a small farm in Uganda with maize crops. The soil is poor in nitrogen. How could a chemical process that converts nitrogen from the air into fertilizer help the farmer?

The Haber process can be used to produce ammonia, which can then be used to create fertilizers. This would allow the farmer to add nitrogen to the soil, improving the growth of the maize crops. The process involves the reaction of nitrogen gas (N_2) and hydrogen gas (H_2) to form ammonia (NH_3), which is then used to produce fertilizers like urea or ammonium nitrate.

What are the challenges of using fertilizers in rural areas? How can we make fertilizers more accessible to farmers in rural areas?

If fertilizers are very expensive in rural areas, what could happen to crop yields without nitrogen fertilizers?

What are the benefits of using fertilizers in rural areas? How can we make fertilizers more accessible to farmers in rural areas?

Can you think of a way the Haber Process could help farmers produce their own fertilizers safely on a small scale?

What are the challenges of using fertilizers in rural areas? How can we make fertilizers more accessible to farmers in rural areas?

2. Food Security

What are the challenges of using fertilizers in rural areas?

Uganda relies heavily on local food production. How might using ammonia-based fertilizers affect food availability in your community?

What are the challenges of using fertilizers in rural areas? How can we make fertilizers more accessible to farmers in rural areas?

Imagine a school garden using only water versus one using fertilizer made from the Haber Process. What differences in growth would you expect and why?

Imagine a school garden using only water versus one using fertilizer made from the Haber Process. What differences in growth would you expect and why?

Why is nitrogen an essential nutrient for plants, and how does the Haber Process make it accessible?

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3. Industry & Jobs

Suppose a small factory in Uganda starts producing ammonia using a scaled-down Haber Process. What jobs could be created locally?

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How might producing fertilizer locally reduce the need to import chemicals from other countries?

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Can the Haber Process be linked to new business opportunities in rural areas? How?

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4. Environmental Considerations

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If too much fertilizer is used, it can pollute rivers. How could knowledge of the Haber Process help farmers use fertilizers more efficiently?

If too much fertilizer is used, it can pollute rivers. How could knowledge of the Haber Process help farmers use fertilizers more efficiently?

Imagine designing an eco-friendly fertilizer using ammonia
produced from air. How would this help both the
environment and agriculture?

Ammonia is a colorless gas with a strong odor. It is used in many
industries, including the production of fertilizers. Ammonia is also
used in the production of explosives and as a refrigerant. It is also
used in the production of many other chemicals. Ammonia is a
very important chemical in many industries.

Water Treatment Process: History, Steps, Importance, and Interesting Facts

Water treatment is a process that purifies water to make it safe for drinking and other uses. It involves several steps, including filtration, disinfection, and distribution. The process is essential for public health and environmental protection.

The concept of water treatment dates back to ancient civilizations. The Romans and Greeks used basic filtration and settling methods to purify water for drinking and public baths.

Over time, water treatment technology has advanced significantly. Modern water treatment plants use a combination of physical and chemical processes to remove contaminants from water. These processes include coagulation, flocculation, sedimentation, filtration, and disinfection. The goal is to produce water that is safe, clean, and palatable.

Modern water treatment began in the 19th century with the discovery that contaminated water could cause diseases such as cholera and typhoid.

Today, water treatment is a complex process that involves many steps and technologies. It is essential for ensuring the safety and quality of the water we drink. Water treatment plants are designed to remove a wide range of contaminants, including bacteria, viruses, and chemicals. The process is constantly monitored to ensure that the water is safe and of high quality.

Steps Involved in Water Treatment

Screening: Large debris such as leaves, sticks, and trash are removed from raw water through screens.

Coagulation and Flocculation: Chemicals like alum are added to water to make tiny particles stick together, forming larger clumps called flocs.

Sedimentation: Flocs settle to the bottom of a tank due to gravity, separating solids from the water.

Filtration: The water is passed through a filter to remove any remaining flocs and other small particles.

Disinfection: The water is treated with a disinfectant, such as chlorine, to kill any remaining bacteria and viruses.

Distribution: The treated water is distributed to homes and businesses through a network of pipes.

Monitoring: The water quality is monitored throughout the treatment process to ensure it is safe to drink.

Filtration: Water passes through sand, gravel, or charcoal filters to remove smaller particles.

Water is filtered through sand, gravel, or charcoal filters to remove smaller particles. This process is called filtration. The water is then treated with chemicals to kill any remaining harmful microorganisms. This process is called disinfection. The water is then stored in tanks or reservoirs before being distributed through pipes to households and industries.

Disinfection: Chemicals such as chlorine or ozone, or ultraviolet light, are used to kill remaining harmful microorganisms.

Water is then treated with chemicals to kill any remaining harmful microorganisms. This process is called disinfection. The water is then stored in tanks or reservoirs before being distributed through pipes to households and industries.

Storage and Distribution: Clean water is stored in tanks or reservoirs before being distributed through pipes to households and industries.

Clean water is stored in tanks or reservoirs before being distributed through pipes to households and industries. The water is then treated with chemicals to kill any remaining harmful microorganisms. This process is called disinfection. The water is then stored in tanks or reservoirs before being distributed through pipes to households and industries.

Why Water Treatment Is Necessary

Water treatment is essential for ensuring that the water we drink is safe and healthy. It removes harmful bacteria, viruses, and parasites, and eliminates harmful chemicals and heavy metals from industrial or agricultural runoff.

Water treatment is vital for health, hygiene, and overall well-being.

It removes harmful bacteria, viruses, and parasites. It also eliminates harmful chemicals and heavy metals from industrial or agricultural runoff.

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It also prevents outbreaks and supports schools, hospitals, and businesses.

In Uganda, proper water treatment prevents outbreaks and supports schools, hospitals, and businesses.

It ensures safe water for drinking, cooking, and cleaning. It also prevents outbreaks and supports schools, hospitals, and businesses.

Fun and Interesting Facts About Water Treatment

The first modern water treatment plant was built in 1854 in London during a cholera outbreak.

Water treatment can remove particles as small as one micron.

UV light kills microorganisms without adding chemicals.

Some water treatment plants use natural wetlands as part of filtration.

Clean water availability is considered a human right and is essential for sustainable development.

Water is a chemical compound made of hydrogen and oxygen atoms. It is essential for life and is found everywhere in the world.

SCENARIOS THAT SHOW SIGNIFICANCE OF WATER TREATMENT PROCESS

Water treatment is a process that removes impurities and contaminants from water to make it safe for drinking and other uses.

1. Household & Personal Use

Water treatment is essential for household and personal use to ensure the safety and health of the community.

Imagine you live in a rural Ugandan village where water comes from a nearby river. What problems might you face if the water is untreated?

Untreated water can contain harmful bacteria, viruses, and parasites that can cause various diseases. It can also contain chemicals and pollutants that can be harmful to health. Drinking untreated water can lead to stomach problems, diarrhea, and other illnesses. It can also affect the taste and smell of the water, making it unpleasant to drink.

How could simple filtration at home (like sand filters) help make water safer for drinking and cooking?

Simple filtration at home, such as using sand filters, can help remove some of the impurities and contaminants from the water. Sand filters work by trapping particles and debris as water passes through the sand. This can help improve the taste and smell of the water and reduce the risk of some waterborne diseases.

What could happen if you drink water that has harmful bacteria or parasites over a long time?

• If you drink water that has harmful bacteria or parasites over a long time, you could get sick. You might have stomach pain, diarrhea, or vomiting. In some cases, it could lead to more serious health problems, especially if you have a weak immune system.

Can you design a small water purification system for your home using materials you can find locally?

• Yes, you can design a small water purification system for your home using materials you can find locally. One simple method is to use a cloth filter made from clean, fine-mesh material like coffee filters or a clean cloth. You can also use activated charcoal, which can be found in some stores or made at home. Another method is to use a small amount of bleach to disinfect the water. Always make sure to use clean materials and follow proper instructions for any purification method you choose.

2. Schools & Community Centers

• A school uses a well that sometimes has cloudy water after heavy rain. How could a water treatment process improve students' health and attendance?

A school uses a well that sometimes has cloudy water after heavy rain. How could a water treatment process improve students' health and attendance?

• If a school uses a well that sometimes has cloudy water after heavy rain, a water treatment process could improve students' health and attendance. Cloudy water often contains sediment and possibly harmful bacteria or parasites. Treating the water, for example, by filtering it through a cloth or using a small amount of bleach, can make it safer to drink. This would reduce the risk of waterborne illnesses, which could lead to fewer sick days and better attendance for students.

How could a small UV light or chlorination system be used in a classroom or community center to make water safe?

What would happen to children if the school did not treat its water? How could that affect learning?

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What would happen to children if the school did not treat its water? How could that affect learning?

3. Agriculture & Farming

What risks exist if the water is untreated?

A farmer wants to use river water for irrigation. What risks exist if the water is untreated?

How could treating irrigation water reduce plant diseases and improve crop yield?

How could treating irrigation water reduce plant diseases and improve crop yield?

How could treating irrigation water reduce plant diseases and improve crop yield?

Can you think of a low-cost method to treat water for small farms in Uganda?

[illegible]

4. Industry & Jobs

A small food-processing business in Uganda needs clean water for cooking and cleaning. What challenges might they face with untreated water?

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840.

How could water treatment create jobs or new business opportunities in the community?

[illegible]

What local industries would benefit most if water treatment was widely available?

[illegible]

What impact does untreated water have on rivers, lakes, and wildlife?

4. Environmental & Public Health

What impact does untreated water have on rivers, lakes, and wildlife?

What impact does untreated water have on rivers, lakes, and wildlife?

What impact does untreated water have on rivers, lakes, and wildlife?

How could water treatment prevent outbreaks of waterborne diseases in villages?

How could water treatment prevent outbreaks of waterborne diseases in villages?

Can students think of ways to combine natural wetlands or solar disinfection to treat water sustainably?

Can students think of ways to combine natural wetlands or solar disinfection to treat water sustainably?

Oil Drilling in Uganda: History, Process, Importance, and Facts

Oil drilling in Uganda is a complex process involving geological exploration, drilling, and production. It is a key source of revenue for the country and has the potential to improve the lives of Ugandans.

History of Oil Discovery in Uganda

The history of oil discovery in Uganda is relatively recent. The first oil was discovered in the Albertine Graben region of western Uganda in 2006.

Oil was first discovered in the Albertine Graben region of western Uganda in 2006.

The discovery of oil in Uganda was a significant event. It opened up new opportunities for the country and its people. The oil industry is now a major source of revenue for the government and a key sector of the economy.

The Albertine Graben is part of the East African Rift System and holds some of Uganda's largest oil reserves.

The Albertine Graben is a tectonic depression in the East African Rift System. It is a key source of oil and gas for the region. The discovery of oil in the Albertine Graben has opened up new opportunities for the country and its people.

Several international companies, including Tullow Oil, TotalEnergies, and CNOOC, partnered with the Ugandan government to develop oil fields.

The development of oil fields in Uganda is a complex process. It involves geological exploration, drilling, and production. The oil industry is now a major source of revenue for the government and a key sector of the economy.

Oil drilling is a complex process that involves several steps, from exploration to production. This document outlines the key stages of oil drilling.

2. Steps Involved in Oil Drilling

The process of oil drilling involves several key steps, including exploration, site preparation, drilling, and production.

1. Exploration

Geologists study the Earth's crust to identify potential oil reservoirs.

- Geologists study the Albertine Graben to locate oil reservoirs using seismic surveys.

Seismic surveys involve creating artificial earthquakes to map the subsurface. This helps geologists identify areas with potential oil reserves. The data is then analyzed to create a 3D model of the subsurface.

2. Site Preparation

Once a site is identified, the land is cleared and prepared for drilling.

- Land is cleared, drilling pads are built, and safety measures are established.

The drilling pad is a large, flat area where the drilling rig is set up. It is surrounded by a fence and other safety measures. The pad is also equipped with water, electricity, and other resources needed for drilling.

3. Drilling the Well

A drill rig bores into the earth, drilling muds maintain pressure and remove rock cuttings.

- A drill rig bores into the earth, drilling muds maintain pressure and remove rock cuttings.

The drilling rig is a large machine that uses a drill bit to bore into the earth. The drill bit is attached to a long pipe that is lowered into the ground. The pipe is filled with drilling mud, which helps to maintain pressure and remove rock cuttings.

Oil is extracted from the well and transported to refineries, gas and water are separated.

4. Well Completion

Steel casings and cement are installed, valves and pumps control oil flow.

- Steel casings and cement are installed, valves and pumps control oil flow.

Oil is extracted from the well and transported to refineries, gas and water are separated.

5. Production

Oil is extracted and transported to refineries, gas and water are separated.

- Oil is extracted and transported to refineries, gas and water are separated.

Oil is extracted from the well and transported to refineries, gas and water are separated.

6. Well Abandonment & Rehabilitation

Non-productive wells are sealed with cement, sites are rehabilitated.

- Non-productive wells are sealed with cement, sites are rehabilitated.

Non-productive wells are sealed with cement, sites are rehabilitated.

Distillation of crude oil.

Crude oil is a mixture of many substances called

hydrocarbons.

These substances have different boiling points.

Distillation is the process used to separate crude oil into

useful fractions based on their boiling points.

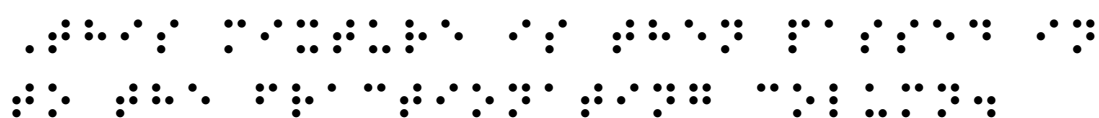
The process takes place in a tall structure called a

fractionating column.

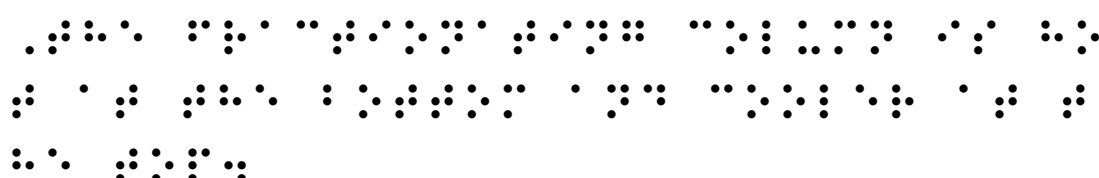
First, crude oil is heated strongly in a furnace until it turns

into a mixture of hot vapours and liquids.

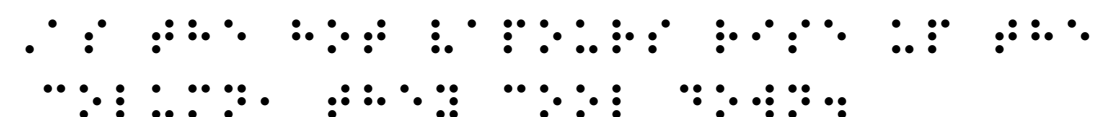
This mixture is then passed into the fractionating column.



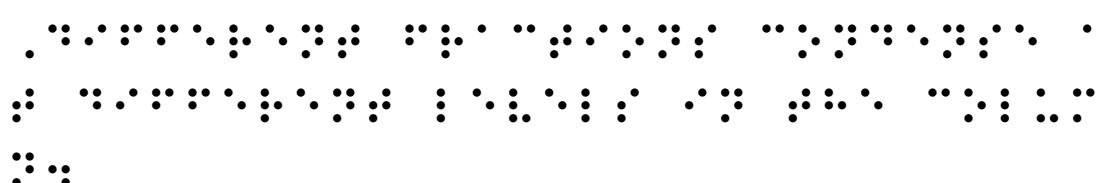
The fractionating column is hot at the bottom and cooler at the top.



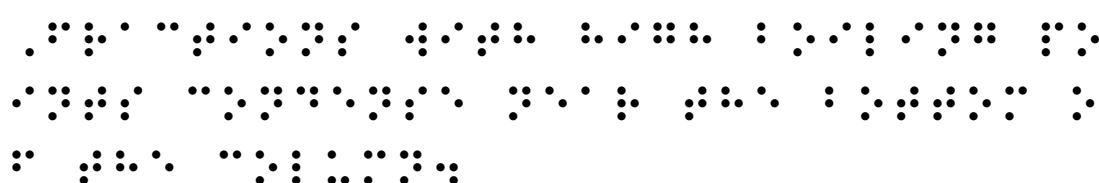
As the hot vapours rise up the column, they cool down.



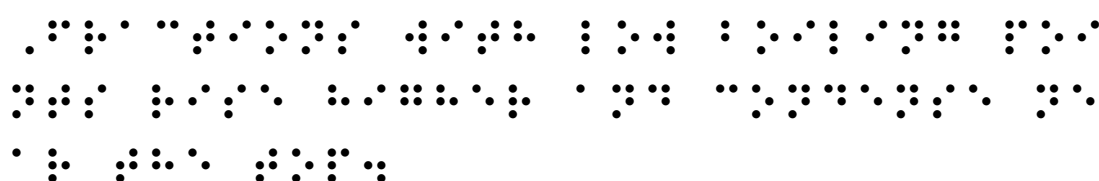
Different fractions condense at different levels in the column.



Fractions with high boiling points condense near the bottom of the column.



Fractions with low boiling points rise higher and condense near the top.



Each fraction is collected separately and used for different purposes.

Each fraction is collected separately and used for different purposes.

Different products are tapped off from the fractionating column at different heights.

Different products are tapped off from the fractionating column at different heights.

The products collected at the top of the column are gases.

The products collected at the top of the column are gases.

These gases are mainly used as fuel for cooking and heating.

These gases are mainly used as fuel for cooking and heating.

Below the gases, petrol is collected.

Below the gases, petrol is collected.

Petrol is used as fuel for cars and motorcycles.

Petrol is used as fuel for cars and motorcycles.

At the bottom of the column, bitumen is collected.

. 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040

Bitumen is used for surfacing roads and roofing buildings.

[illegible]

3. Why Oil Drilling Is Necessary

The Braille representation of the sentence "The cat sat on the mat." consists of the following dots:
 - T: 2-3-4
 - h: 2-3-6
 - e: 2-3-4-6
 - s: 2-3-4-6
 - p: 2-3-4-5-6
 - a: 2-3-4-6
 - t: 2-3-4
 - s: 2-3-4-6
 - a: 2-3-4-6
 - t: 2-3-4
 - o: 2-3-4-5-6
 - n: 2-3-4-6
 - t: 2-3-4
 - h: 2-3-6
 - e: 2-3-4-6
 - m: 2-3-4-5-6
 - a: 2-3-4-6
 - t: 2-3-4

- Oil is a major energy source for Uganda.



- Revenue funds infrastructure, healthcare, and education.

[illegible]

- It creates jobs and supports local communities.

[illegible]

- Oil products are used in transportation, electricity, and manufacturing.

[illegible]

Oil is a fossil fuel that is formed from the remains of ancient plants and animals. It is a non-renewable resource that is used to produce energy and transport. Oil is a complex mixture of hydrocarbons and other organic compounds. It is a dark, viscous liquid that is found in underground reservoirs. Oil is a major source of energy and is used in a wide range of products, including gasoline, diesel, and kerosene. It is also used in the production of plastics, fertilizers, and other chemicals. Oil is a valuable resource, but it is also a major source of environmental pollution. The burning of oil releases greenhouse gases, which contribute to climate change. Oil spills can also cause significant damage to the environment and to human health. Therefore, it is important to use oil responsibly and to find alternative sources of energy.

4. Fun and Interesting Facts

Oil is a complex mixture of hydrocarbons and other organic compounds.

- The Albertine Graben has about 6.5 billion barrels of oil.

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- First commercial production is planned via Tilenga and Kingfisher projects.

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SCENARIOS THAT SHOW SIGNIFICANCE OF OIL DRILLING

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In the Albertine region, a new oil well is being drilled near a village. The villagers are excited because the project promises jobs and electricity for schools. However, an accidental spill threatens the nearby river, which provides water for drinking and fishing. Blind students imagine being part of a team that monitors the river, feeling raised-line maps and using tactile indicators to mark safe and risky areas. They brainstorm ways to balance employment

and environmental safety.

Braille representation of the text above.

The local government plans to use oil revenue to build a clinic and new roads. While construction begins, the air near the drilling site becomes polluted with smoke and gas. Blind learners imagine walking through the area safely with sound cues indicating clean and polluted zones, and they think about designing routes and facilities that reduce exposure to pollution.

Braille representation of the text above.

Braille representation of the text in the first block.

A factory near the drilling site needs oil for production, but one day a pipeline leak threatens to contaminate Lake Albert. Blind learners imagine pouring water in a tray to represent the lake and using tactile barriers to contain the “spill.” They role-play how local communities respond and protect fish and water sources.

Braille representation of the text in the second block.

Biogas production is a natural process where microorganisms break down organic matter without oxygen. The process is called anaerobic digestion. It is a natural process that occurs in the soil and in the digestive tracts of animals. It is a natural process that occurs in the soil and in the digestive tracts of animals.

Biogas Production: History, Mechanism, Importance, and Facts

Biogas production is a natural process where microorganisms break down organic matter without oxygen. The process is called anaerobic digestion. It is a natural process that occurs in the soil and in the digestive tracts of animals. It is a natural process that occurs in the soil and in the digestive tracts of animals.

1. History of Biogas Production

Biogas production has its roots in anaerobic digestion, a natural process where microorganisms break down organic matter without oxygen.

The first modern biogas plant was built in the 1850s in India and Europe, mainly for lighting and cooking. The first modern biogas plant was built in the 1850s in India and Europe, mainly for lighting and cooking. The first modern biogas plant was built in the 1850s in India and Europe, mainly for lighting and cooking.

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Over time, the process has evolved into industrial-scale biogas plants that convert agricultural waste, food waste, and animal dung into biogas, which is a clean energy source.

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2. Steps Involved in Biogas Production

Biogas is produced through the anaerobic digestion of organic matter.

Biogas is produced through the anaerobic digestion of organic matter.

Step 1: Collection of organic waste

Animal dung, crop residues, and food waste are gathered in a digester.

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• The waste is sealed in a digester where bacteria break it down in the absence of oxygen.

Step 2: Anaerobic digestion

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Step 3: Biogas collection

• The produced biogas is collected in a storage dome above the digester.

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Step 4: Utilization

• Biogas can be used for cooking, heating, electricity generation, or as vehicle fuel.

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When the slurry is ready, it is used to feed the biogas plant. The slurry is mixed with water and fed into the digester. The digester is a large tank where the slurry is broken down by bacteria. The bacteria produce biogas, which is collected and used for cooking or heating. The leftover slurry, called digestate, is rich in nutrients and can be used as organic fertilizer.

Step 5: Use of digestate

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3. Why Biogas Production Is Necessary

Biogas production provides clean, renewable energy, reduces greenhouse gas emissions, produces organic fertilizer, manages waste, and supports rural livelihoods.

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4. Fun and Interesting Facts About Biogas Production

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SCENARIOS THAT SHOW THE SIGNIFICANCE OF BIO GAS PRODUCTION

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1. Household Energy and Sanitation



In a rural Ugandan village, a family struggles with expensive firewood and smoky cooking stoves.

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A student notices that the household produces a lot of animal dung and kitchen waste.

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The student designs a small biogas digester that converts this waste into clean cooking gas.

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100.

The leftover slurry is used as fertilizer for their vegetable garden.

[illegible]

Blind learners can explore how biogas stoves can be operated safely using tactile indicators and sound cues.

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840.

2. School Energy Projects

At a local secondary school, students notice that the school kitchen produces a lot of food waste daily.

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840.

They decide to collect the food waste and design a biogas plant prototype to power the school's kitchen stove.

Blind students contribute by sensing the gas flow through sound-based gauges and helping monitor the system.

This project teaches energy sustainability, waste management, and teamwork.

3. Community Sanitation and Agriculture

They decide to collect the food waste and design a biogas plant prototype to power the school's kitchen stove.

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3. Community Sanitation and Agriculture

They decide to collect the food waste and design a biogas plant prototype to power the school's kitchen stove.

A community near a swampy area faces foul odors from animal pens and stagnant water.

[illegible]

Students identify that biogas production can solve sanitation problems by processing animal dung and human waste.

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840.

The biogas produced powers small lamps and stoves, while the digestate improves soil for community gardens.

[illegible]

Blind learners can monitor the fermentation process by touch and smell, gaining hands-on experience in microbiology.

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840.

4. Rural Electrification

In a small Ugandan village without electricity, students build a biogas generator that powers LED lamps in homes.

[illegible]

They use cow dung and crop residues as feedstock. Blind learners participate by learning tactile wiring and sound-based fuel level indicators.

[illegible]

This scenario highlights renewable energy and inclusive innovation.

[illegible]

5. Biogas for Small Businesses

A student observes a local bakery struggling with expensive charcoal.

• 1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840.

They propose a biogas system using leftover food waste to power the ovens.

[illegible]

Blind students help test the safety and efficiency of gas usage through sound and vibration cues.

[illegible]

This shows the commercial potential of biogas in everyday life.

[illegible]

6. Environmental Awareness Campaigns

Students design a community awareness project about reducing methane emissions from waste.

They demonstrate how biogas plants capture methane and turn it into useful energy, reducing greenhouse gases.

Blind learners contribute by creating tactile models and Braille guides, helping teach others about sustainable energy.

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Fermentation of alcohols

Chemical reaction for the fermentation of alcohols:

Fermentation is an ancient process used by humans for thousands of years to produce food and beverages such as bread, beer, and yogurt.

The process of fermentation involves the conversion of sugars into alcohol and carbon dioxide by the action of microorganisms. This process is used in the production of various alcoholic beverages, including beer, wine, and spirits. The microorganisms used in fermentation are typically yeast, which are single-celled fungi that can convert sugars into alcohol and carbon dioxide.

Evidence of fermentation dates back to 7000–6600 BCE in China for rice wine and 6000 BCE in Mesopotamia for beer production.

The process of fermentation is a complex biochemical reaction that involves the conversion of sugars into alcohol and carbon dioxide. The reaction is catalyzed by the enzyme alcohol dehydrogenase, which is produced by the microorganisms used in fermentation. The reaction is reversible, meaning that alcohol can be converted back into sugar by the action of the same enzyme.

Louis Pasteur demonstrated in the 19th century that fermentation is caused by microorganisms, not a purely chemical reaction.

Pasteur's experiments showed that fermentation is a biological process that requires the presence of living microorganisms. He demonstrated that the fermentation of sugar into alcohol and carbon dioxide is caused by the action of yeast, which are microorganisms that can convert sugars into alcohol and carbon dioxide.

Glucose is a six-carbon sugar. It is a monosaccharide, meaning it is a single sugar molecule. It is the primary source of energy for most organisms. It is broken down into pyruvate, which can then be used for energy production.

Fermentation occurs in anaerobic conditions, meaning without oxygen.

There are two main types of fermentation: alcoholic fermentation and lactic acid fermentation. Alcoholic fermentation is used to produce beer and wine. Lactic acid fermentation is used to produce yogurt and cheese.

Key enzymes involved include zymase, maltase, lactate dehydrogenase, and invertase.

Zymase is an enzyme that catalyzes the conversion of glucose into ethanol and carbon dioxide. Maltase is an enzyme that breaks down maltose into glucose. Lactate dehydrogenase is an enzyme that converts glucose into lactic acid. Invertase is an enzyme that breaks down sucrose into glucose and fructose.

Zymase catalyzes glucose into ethanol and carbon dioxide:

$$\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 2\text{C}_2\text{H}_5\text{OH} + 2\text{CO}_2$$

Maltase breaks maltose into glucose:

$$\text{C}_{12}\text{H}_{22}\text{O}_{11} + \text{H}_2\text{O} \rightarrow 2\text{C}_6\text{H}_{12}\text{O}_6$$

Lactate dehydrogenase converts glucose to lactic acid:

$$\text{C}_6\text{H}_{12}\text{O}_6 + \text{NAD}^+ \rightarrow \text{C}_3\text{H}_7\text{O}_3 + \text{NADH} + \text{H}^+$$

Invertase breaks sucrose into glucose and fructose.

[illegible]

Fermentation is important for food production, biofuels, pharmaceuticals, agriculture, and waste management.

[illegible]

Fermentation occurs in anaerobic conditions and can preserve food naturally.

[illegible]

Fermentation is important for producing food such as bread, yogurt, cheese, beer, and wine.

[illegible]

Fermentation produces biofuels such as ethanol which can be used as sustainable energy.

۱- در صورتی که به دلیل عدم امکان حضور در محل برگزاری آزمون، نیاز به درخواست مرخصی باشد، متقاضیان باید حداکثر تا یک هفته قبل از تاریخ برگزاری آزمون، مراتب را به اطلاع مسئول مربوطه برسانند.
 ۲- در صورتی که به دلیل بیماری یا سایر علل غیر قابل پیش بینی، نیاز به درخواست مرخصی باشد، متقاضیان باید حداکثر تا یک هفته بعد از تاریخ برگزاری آزمون، مراتب را به اطلاع مسئول مربوطه برسانند.
 ۳- در صورتی که به دلیل تغییرات ناخواسته در برنامه کاری، نیاز به درخواست مرخصی باشد، متقاضیان باید حداکثر تا یک هفته بعد از تاریخ برگزاری آزمون، مراتب را به اطلاع مسئول مربوطه برسانند.

Fermentation is used in pharmaceuticals to produce antibiotics, vitamins, and vaccines.

Pharmaceutical fermentation involves the use of microorganisms to produce a wide range of products. These include antibiotics, vitamins, and vaccines. The process typically involves the cultivation of microorganisms in a nutrient-rich medium, followed by the extraction and purification of the desired product.

Fermented agricultural residues can be used as animal feed to improve digestibility.

Fermented agricultural residues, such as silage, are commonly used as animal feed. The fermentation process breaks down complex carbohydrates into simpler sugars, making the feed more digestible for animals. This can lead to improved growth and health in livestock.

Fermentation helps preserve food naturally without refrigeration.

Fermentation is a natural process that can be used to preserve food. By creating an acidic environment, fermentation inhibits the growth of spoilage bacteria and molds. This allows food to be stored for longer periods without the need for refrigeration.

Fun fact: Lactic acid fermentation is what makes yogurt sour and pickles tangy.

Lactic acid fermentation is a process where bacteria convert sugars into lactic acid. This acid gives yogurt its characteristic sour taste and pickles their tangy flavor. It is a common method for preserving dairy and vegetable products.

Fun fact: Yeast can convert sugar to alcohol in as little as 2–3 days.

Yeast fermentation is a process where yeast converts sugars into alcohol and carbon dioxide. This process is used in the production of beer, wine, and other alcoholic beverages.

Industrial fermentation is a multibillion-dollar global industry.

Fun fact: Industrial fermentation is a multibillion-dollar global industry.

Fermentation can help recycle agricultural residues into useful products.

Fun fact: Fermentation can help recycle agricultural residues into useful products.

Fermentation can help recycle agricultural residues into useful products.

Fermentation Assignment Scenarios

1. How can you, as a blind student, produce yogurt at home using lactic acid fermentation to improve your family's nutrition? Describe the steps you would follow and how you can monitor the process without sight.

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Describe the steps you would follow and how you can monitor the process without sight.

Braille representation of the text above.

2. Your school science club wants to demonstrate yeast fermentation by making bread. How can blind and sighted students work together to feel, listen, and measure the dough's rising process? What scientific principles can you learn from this activity?

Braille representation of the text above.

3. Imagine your community wants to convert sugarcane residues into ethanol biofuel. As a student, including blind learners, how would you design a safe, practical experiment to demonstrate fermentation and produce usable fuel?

Braille representation of the text above.

Braille representation of the text above the first question.

4. You have the opportunity to visit a small factory producing fermented products like cheese and beer. How can blind students learn about the enzymatic processes (zymase, maltase) and the role of fermentation in industry using tactile tools and guides?

Braille representation of the text above the second question.

5. How can students use simple fermentation to create probiotic drinks and understand how microbes produce useful compounds like vitamins or antibiotics? Include steps to make this experiment accessible for blind students.

Braille representation of the text above the third question.

Braille representation of the text above the question.

6. You want to convert leftover fruit and vegetable waste into fermented animal feed. How can blind students safely participate in this project and learn how fermentation improves digestibility and reduces waste?

Braille representation of the text below the question.

Soap & Detergent Manufacture

1. History / Background

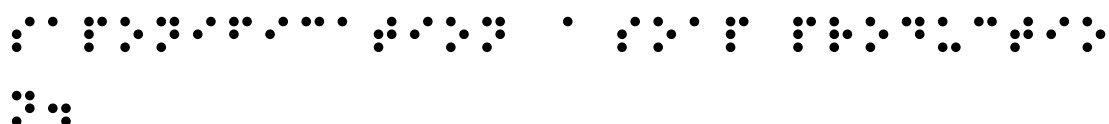
Soap making has been practiced for thousands of years, with early evidence from ancient Babylon (around 2800 BCE). Traditional soaps were made by boiling animal fats with wood ash. Detergents were developed in the 20th century to clean more effectively in hard water and industrial environments. Modern soap and detergent manufacture relies on chemistry of acids, bases, and esters.

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840.

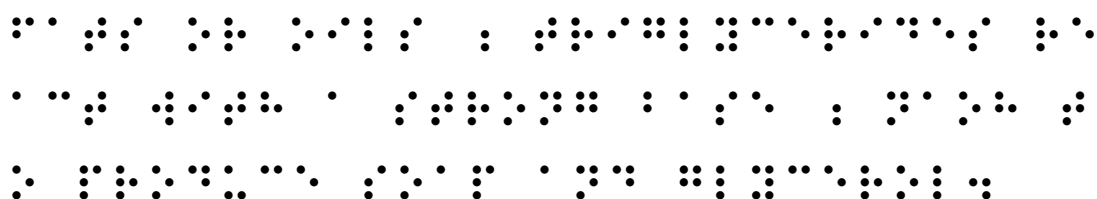
Steps / Mechanism



Saponification (Soap Production)



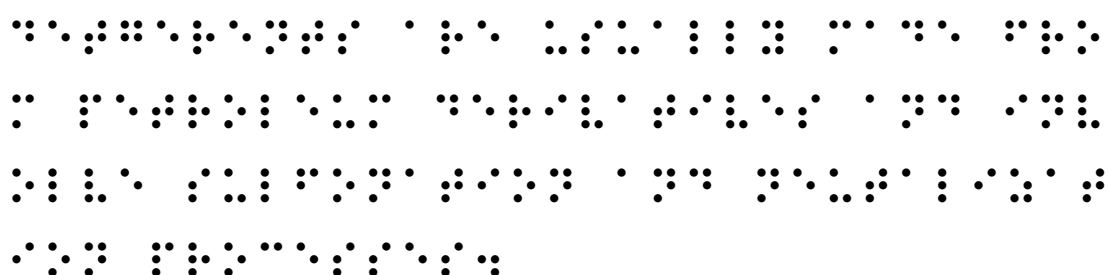
Fats or oils (triglycerides) react with a strong base (like NaOH) to produce soap and glycerol:



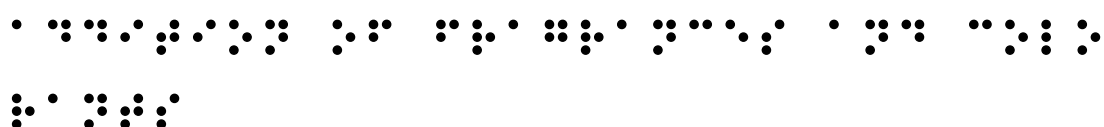
Detergent Production



Detergents are usually made from petroleum derivatives and involve sulfonation and neutralization processes.



Addition of Fragrances and Colorants



To make soap more appealing, perfumes and dyes are added.

Braille representation of the text above.

Molding and Packaging

Braille representation of the section header.

The mixture is poured into molds, allowed to solidify, cut, and packaged for sale.

Braille representation of the text above.

PRACTICAL SCENARIO

Braille representation of the section header.

A group of blind students in a community school wants to make natural soap.

Braille representation of the text above.

They decide to use sim-sim seeds because these seeds are rich in oil.

Braille representation of the text above.

The students then pour the paste into molds and allow it to harden over several days.

[illegible]

At the end, they have natural, fragrant soap made entirely from sim-sim seeds.

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840.

Which can be used for personal hygiene or sold to the community.












Showing both creativity and practical application of chemistry.

[illegible]

Importance: Why Necessary

Soap and detergents are essential for maintaining hygiene and preventing the spread of diseases.

- Soap and detergents promote hygiene and prevent disease.

They are used in various settings, including homes, schools, hospitals, and industries, to ensure cleanliness and reduce the risk of infection.

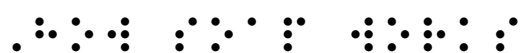
- They are essential in households, schools, hospitals, and industries.

Understanding the chemical properties of soaps and detergents, such as their ability to emulsify oils and remove dirt, helps students appreciate the science behind everyday cleaning products.

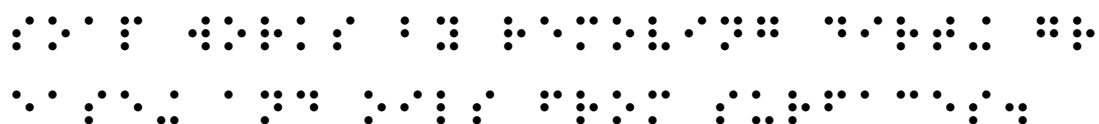
- Understanding acids, bases, and esters helps students see chemistry in everyday life.

By studying these topics, students can better understand the chemical processes involved in common household items and their interactions with the environment, fostering a deeper appreciation for chemistry in daily life.

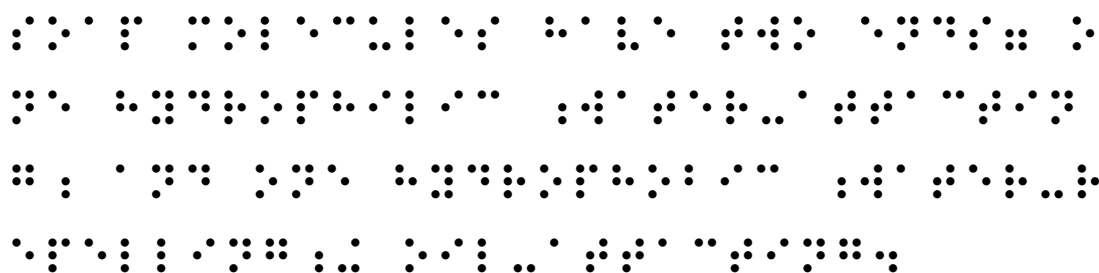
How soap works



Soap works by removing dirt, grease, and oils from surfaces.



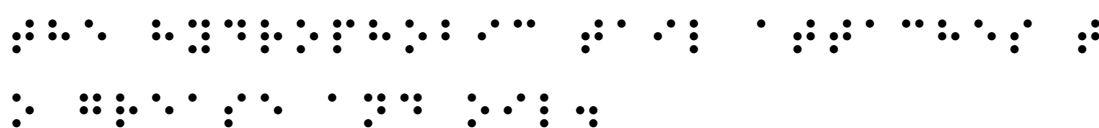
Soap molecules have two ends: one hydrophilic (water-attracting) and one hydrophobic (water-repelling, oil-attracting).



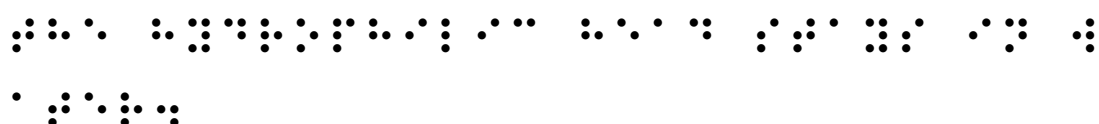
When you wash with soap:



The hydrophobic tail attaches to grease and oil.

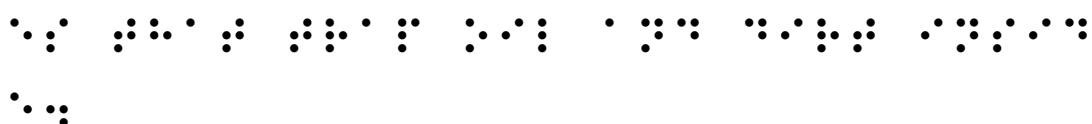


The hydrophilic head stays in water.

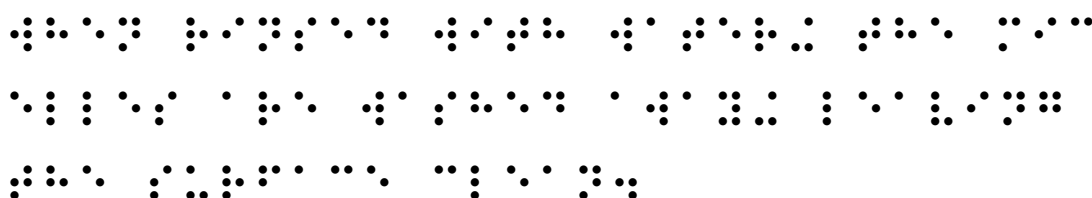


This forms micelles—tiny spheres that trap oil and dirt inside.

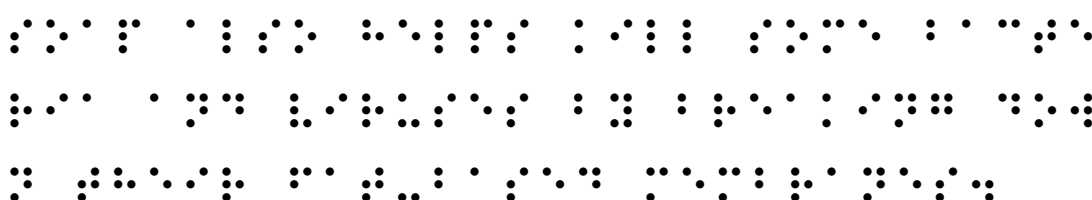




When rinsed with water, the micelles are washed away, leaving the surface clean.



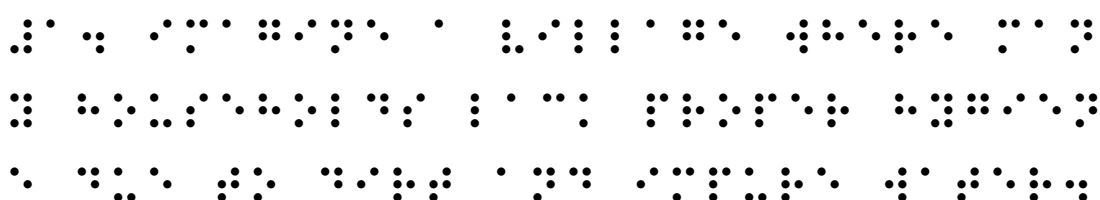
Soap also helps kill some bacteria and viruses by breaking down their fat-based membranes.



SCENARIOS THAT SHOW SIGNIFICANCE OF SAPONIFICATION

1.

Imagine a village where many households lack proper hygiene due to dirt and impure water.



How could you, using sim-sim seeds, produce soap that helps your family and neighbors stay clean?



[illegible]

2.

Your school dormitory has limited soap for students.

Figure 1: A diagram illustrating the structure of the input data. The input is a sequence of 1000 samples, each represented by a vector of 100 features. The features are grouped into 10 clusters, each represented by a different color. The clusters are labeled 1 through 10. The diagram shows the input data as a grid of 1000 samples, with each sample being a vector of 100 features. The features are grouped into 10 clusters, each represented by a different color. The clusters are labeled 1 through 10. The diagram shows the input data as a grid of 1000 samples, with each sample being a vector of 100 features. The features are grouped into 10 clusters, each represented by a different color. The clusters are labeled 1 through 10.

How could a group of visually impaired students use avocado seeds or coconut oil to make enough soap for everyone?

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3.

You notice a demand for affordable natural soap in your local market.

[illegible]

How could you extract oil from sunflower seeds and produce soap to sell, creating jobs and promoting

hygiene?

How can we ensure that the community has enough soap during a disease outbreak?

4.

Used cooking oil is being poured into local rivers, causing pollution.

How can we ensure that the community has enough soap during a disease outbreak?

How could you collect vegetable oil and turn it into soap, while teaching your community about saponification?

How can we ensure that the community has enough soap during a disease outbreak?

5.

A local health center wants to ensure the community has enough soap during a disease outbreak.

How can we ensure that the community has enough soap during a disease outbreak?

How could students, including blind learners, use palm kernel oil to produce enough soap for the community?

How could students, including blind learners, use palm kernel oil to produce enough soap for the community?

How could students, including blind learners, use palm kernel oil to produce enough soap for the community?

6.

After a flood, homes lack soap.

How could blind and sighted students use animal fats like tallow or suet to make soap for affected families?

How could blind and sighted students use animal fats like tallow or suet to make soap for affected families?

How could blind and sighted students use animal fats like tallow or suet to make soap for affected families?

Extraction of Iron: History, Steps, Importance, and Fun Facts

Extraction of iron is a process that involves removing iron from its ores. This process has been used for thousands of years and is still an important part of modern industry.

1. History of Iron Extraction

Iron has been used by humans for thousands of years.

The earliest iron was obtained from meteoric iron, which was already pure and could be hammered into tools. This was the only source of iron for early humans.

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By around 1200 BCE, humans learned to extract iron from iron ores like hematite and magnetite using furnaces. This was a major breakthrough in the history of iron extraction.

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This process involved heating the ores in a furnace to melt them and then pouring the molten metal into a mold. This was a major breakthrough in the history of iron extraction.

Modern extraction uses blast furnaces, developed in the Industrial Revolution, allowing large-scale iron production.

This process involves heating the ores in a furnace to melt them and then pouring the molten metal into a mold.

Iron is a transition metal. It is found in the d-block of the periodic table. It is a solid at room temperature and has a high melting point. It is a good conductor of electricity and is used in many alloys.

Steps Involved in the Extraction of Iron

The extraction of iron involves several steps, including the collection of iron ore, preparation of the ore, and loading the blast furnace.

Collection of Iron Ore

Iron ore, usually hematite or magnetite, is collected from mines.

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The ore is then crushed and concentrated by removing impurities.

Preparation of the Ore

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Loading the Blast Furnace

The ore is then crushed and concentrated by removing impurities.

Iron ore, coke, and limestone are layered in the furnace.

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Heating

Hot air is blown in; coke burns, producing heat and carbon monoxide.

Hot air is blown in; coke burns, producing heat and carbon monoxide.

Hot air is blown in; coke burns, producing heat and carbon monoxide.

Chemical Reactions

Combustion of Coke: Coke burns, producing heat and carbon monoxide. (explained in words)

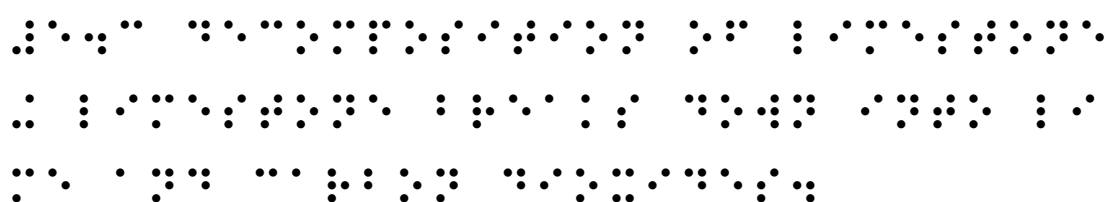
- Combustion of Coke: Coke burns, producing heat and carbon monoxide.

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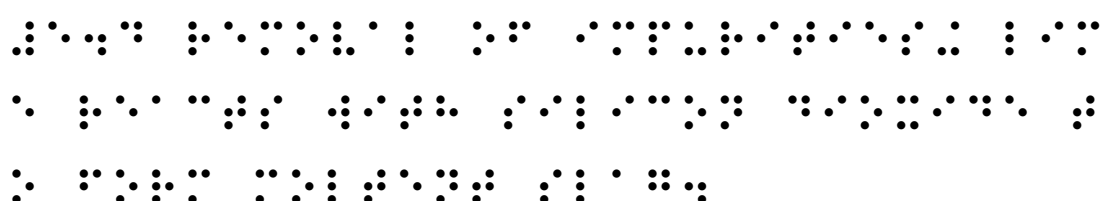
- Reduction of Iron Ore: Carbon monoxide removes oxygen from iron ore, leaving molten iron.

Reduction of Iron Ore: Carbon monoxide removes oxygen from iron ore, leaving molten iron.

- Decomposition of Limestone: Limestone breaks down into lime and carbon dioxide.



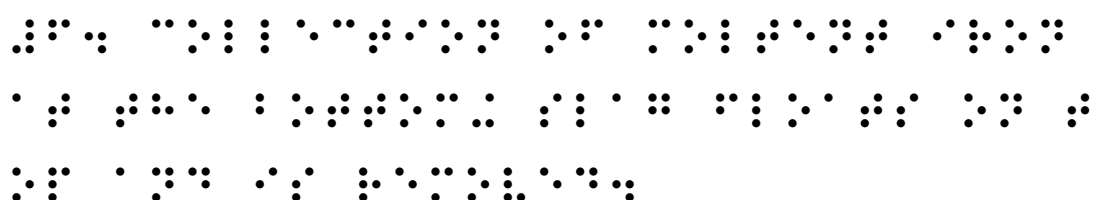
- Removal of Impurities: Lime reacts with silicon dioxide to form molten slag.



Collection of Molten Iron



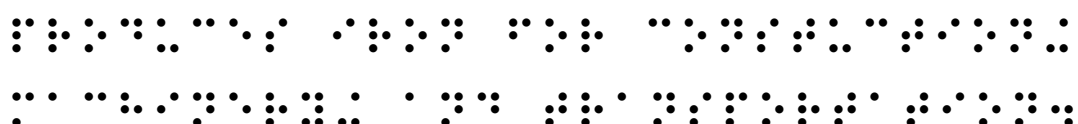
Molten iron collects at the bottom; slag floats on top and is removed.



Importance of Iron Extraction



Produces iron for construction, machinery, and transportation.



Forms the basis of steel production, which supports industrial growth.

Iron is the most used metal in the world. It is the basis of steel production, which supports industrial growth.

Creates jobs in mining, transport, and manufacturing.

Iron is used in many industries, including mining, transport, and manufacturing.

Fun Facts

Iron is the most used metal in the world.

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Iron is the most used metal in the world. It is the basis of steel production, which supports industrial growth.

The blast furnace can reach temperatures of about 2000°C.

The blast furnace can reach temperatures of about 2000°C. It is used to produce pig iron, which is then refined into steel.

Iron extracted in a blast furnace is called pig iron due to the traditional shape of molds.

Iron extracted in a blast furnace is called pig iron due to the traditional shape of molds. It is then refined into steel, which is used in many industries.

Modern iron extraction is highly efficient and recycles slag into cement.

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Narrative Assignment Scenarios: Importance of Iron Extraction

You are a blind student living in a rural village where farmers struggle because their tools break easily.

1. The Village Tool Maker

You are a blind student living in a rural village where farmers struggle because their tools break easily.

You are asked to explain to the community how extracting iron from iron ore can help produce strong farming tools.

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2. The School Workshop Leader

You are a blind learner chosen to lead a school workshop project.

You must explain why iron extraction is important for making strong desks, doors, and window grills.

[illegible]

3. The Community Employment Advocate

Figure 6

Figure 6 displays two rows of Braille characters. The top row contains five groups of Braille, each consisting of a single character followed by a space. The bottom row contains three groups of Braille, each consisting of a single character followed by a space.

You are invited to explain how iron extraction creates jobs in mining, transport, and manufacturing.

[illegible]

Braille representation of the text above the section header.

4. The Transportation Problem Solver

Braille representation of the text above the paragraph.

You are tasked with explaining how iron extraction supports bridges, vehicles, and railways.

Braille representation of the text above the section header.

5. The Science Fair Demonstrator

Braille representation of the text above the paragraph.

You demonstrate iron extraction using touch, sound, and explanation.

Braille representation of the text above the section header.

Extraction of copper (kilembe mines, Kasese – Uganda)

Extraction of copper (Kilembe mines, Kasese – Uganda)

1. History of Copper Extraction (Kilembe Mines, Kasese)

Copper mining in Uganda is mainly associated with Kilembe Mines located in Kasese District.

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Copper was discovered at Kilembe in the early 20th century, and large-scale mining began in the 1950s.

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Copper ore is obtained by underground mining at Kilembe because the ore lies deep beneath the surface.

2. Mining of Copper Ore

Copper ore is obtained by underground mining at Kilembe because the ore lies deep beneath the surface.

Copper ore is obtained by underground mining at Kilembe because the ore lies deep beneath the surface.

When the ore is mined, it is often found in a form that is not pure. It may contain other minerals and impurities. The first step in the process of extracting a metal from its ore is to crush the ore into smaller pieces and then grind it into a fine powder.

3. Crushing and Grinding

The mined ore is crushed into smaller pieces and then ground into a fine powder.

The mined ore is crushed into smaller pieces and then ground into a fine powder.

The powdered ore is mixed with water and chemicals, then air is blown through it. The air bubbles attach to the copper-containing particles, which float to the surface. The waste material sinks to the bottom and is discarded.

4. Concentration of the Ore

The powdered ore is mixed with water and chemicals, then air is blown through it.

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The air bubbles attach to the copper-containing particles, which float to the surface. The waste material sinks to the bottom and is discarded.

Copper-containing particles attach to air bubbles and float, while waste sinks.

The powdered ore is mixed with water and chemicals, then air is blown through it.

• $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$ • $\frac{1}{2} \times \frac{1}{4} = \frac{1}{8}$ • $\frac{1}{4} \times \frac{1}{4} = \frac{1}{16}$ • $\frac{1}{2} \times \frac{1}{8} = \frac{1}{16}$ • $\frac{1}{4} \times \frac{1}{8} = \frac{1}{32}$ • $\frac{1}{8} \times \frac{1}{8} = \frac{1}{64}$

• $\frac{1}{2} \times \frac{1}{16} = \frac{1}{32}$ • $\frac{1}{4} \times \frac{1}{16} = \frac{1}{64}$ • $\frac{1}{8} \times \frac{1}{16} = \frac{1}{128}$

ENVIRONMENTAL IMPACT OF COPPER EXTRACTION IN UGANDA

[illegible]

A Narrative from the Kilembe Mines

Kilembe Mines, located in the foothills of the Rwenzori Mountains in western Uganda, were once among the country's most important copper mining areas.

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840.

For many years, copper extraction at Kilembe supported Uganda's economy by providing raw materials, employment, and export earnings.

[illegible]

During the mining activities, large quantities of copper ore were mined and processed. The ore was roasted and smelted.

However, the mining activities also left lasting environmental effects on the surrounding communities and natural resources.

During copper extraction at Kilembe, large quantities of copper ore were mined and processed. The ore was roasted and smelted.

These processes released sulfur dioxide gas into the air.

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As part of the extraction process, the ore was roasted and smelted.

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These processes released sulfur dioxide gas into the air.

During the mining activities, large quantities of copper ore were mined and processed. The ore was roasted and smelted.

Over time, this gas affected the quality of air breathed by nearby communities.

Uses of Copper in Uganda

Copper is used in electrical wiring and electronics because it conducts electricity well.

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840.

It is used in plumbing and roofing because of its resistance to corrosion.

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840.

Copper is important in making coins and medals.

Figure 1. The 16 stimuli used in the experiment. The stimuli are arranged in two rows of eight. Each stimulus consists of a set of black dots on a white background, forming various patterns that resemble letters or symbols.

It is used in industrial machinery and manufacturing of equipment.

[illegible]

It is used in the production of alloys such as bronze and brass.

Copper is used in producing alloys such as bronze and brass.

It is used in the production of alloys such as bronze and brass.

It contributes to economic development by providing raw materials for industries.

It is used in the production of alloys such as bronze and brass.

Industrial Distillation of Liquefied Air

Industrial distillation of liquefied air is a process used to separate the components of air, such as oxygen, nitrogen, and argon, into their pure forms. This process is essential for the production of many industrial gases and for scientific research.

History of Industrial Air Distillation

The history of industrial air distillation dates back to the late 19th century, when scientists first began to study the properties of air and its components. The process was developed to separate oxygen, nitrogen, and other gases for industrial and medical uses.

The industrial distillation of air began in the late 19th century.

It was developed to separate oxygen, nitrogen, and other gases for industrial and medical uses.

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Necessity of Air Distillation

It is necessary because pure oxygen, nitrogen, and argon are needed in medicine, industry, and scientific research.

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The Process of Industrial Air Distillation

Industrial air distillation is a process used to separate the components of air into pure gases and liquids. This process involves several steps, including air compression, cooling, liquefaction, and fractional distillation.

1. Air Compression

Atmospheric air is filtered to remove dust and compressed to high pressure.

Atmospheric air is filtered to remove dust and compressed to high pressure.

The compressed air is then cooled using heat exchangers. This process is repeated several times to ensure the air is cooled to the required temperature for liquefaction.

2. Air Cooling

The compressed air is cooled using heat exchangers.

The compressed air is cooled using heat exchangers.

The cooled air is then expanded rapidly to produce very low temperatures, turning it into liquid air.

3. Air Liquefaction

Cooled air is expanded rapidly to produce very low temperatures, turning it into liquid air.

Cooled air is expanded rapidly to produce very low temperatures, turning it into liquid air.

The liquid air is then separated into its components using fractional distillation. This process involves passing the liquid air through a series of trays or columns, where the different components of the air are separated based on their boiling points.

4. Fractional Distillation

The liquid air is then separated into its components using fractional distillation.

Liquid air is slowly warmed in a fractionating column, and gases separate based on boiling points: nitrogen, argon, then oxygen.

Braille representation of the text above.

5. Collection of Gases

Braille representation of the section header.

Separated gases are collected in storage tanks for industrial, medical, and scientific use.

Braille representation of the text above.

Fun Facts

Braille representation of the section header.

1. Nitrogen makes up about 78% of the air we breathe.

Braille representation of the text above.

2. Oxygen supports combustion and is used in welding and medical treatments.

Braille representation of the text above.

• Argon is used in the production of metal alloys and in the welding of metal pipes.

3. Argon is inert and prevents oxidation in metal production.

• Argon is used in the production of metal alloys and in the welding of metal pipes.

Impact of Industrial Distillation of Liquefied Air

• The process of industrial distillation of liquefied air is used to separate the components of air into pure gases.

Scenario 1: Medical Use of Oxygen

• In Uganda, hospitals rely on industrial oxygen for treating patients with respiratory illnesses and during surgeries.

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• The process of industrial distillation of liquefied air is used to separate the components of air into pure gases.

This has improved survival rates in critical care and reduced fatalities from respiratory infections.

• The process of industrial distillation of liquefied air is used to separate the components of air into pure gases.

Assignment: Describe two ways industrial oxygen improves healthcare outcomes in Uganda.

• Industrial oxygen is used in the production of medical equipment and supplies, such as oxygen tanks and ventilators, which are essential for healthcare facilities. This ensures that patients receive the necessary oxygen therapy, improving their recovery and overall health outcomes.

Scenario 2: Industrial Applications

Industrial oxygen is used in various sectors, including steel production, welding, and chemical manufacturing. This oxygen is produced through air distillation.

Industries such as steel production, welding, and chemical manufacturing use oxygen and nitrogen produced through air distillation.

This process involves separating the components of air, such as oxygen and nitrogen, which are then used in various industrial processes. For example, oxygen is used in steel production to remove impurities, while nitrogen is used in welding to create strong, durable joints. This industrial oxygen is produced through air distillation.

This has boosted manufacturing efficiency, supporting economic growth and job creation.

The use of industrial oxygen in manufacturing has led to significant improvements in efficiency and quality. This has resulted in faster production times and lower costs, which has helped to boost the economy and create new jobs.

Assignment: Identify three industries in Uganda that benefit from industrial oxygen and explain how.

Industrial gases are used in various processes, including the production of fertilizers, pharmaceuticals, and plastics. These gases are essential for many industries and are used in a wide range of applications.

Scenario 3: Scientific Research and Education

Universities and research centers use industrial gases for experiments, supporting innovation and technological advancement.

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Industrial gases are used in various processes, including the production of fertilizers, pharmaceuticals, and plastics. These gases are essential for many industries and are used in a wide range of applications.

Assignment: Give two examples of scientific experiments in Uganda that use industrial gases and explain their importance.

Industrial gases are used in various processes, including the production of fertilizers, pharmaceuticals, and plastics. These gases are essential for many industries and are used in a wide range of applications.

History of Cement in Uganda

[illegible]

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• • • • •

Why Cement Mining is Necessary

[illegible][illegible]

Cement Mining Process

The image shows three Braille dot patterns. The first pattern has dots 1, 2, 3, 4, 5, and 6, representing the number 1. The second pattern has dots 1, 2, 3, 4, 5, and 6, representing the number 2. The third pattern has dots 1, 2, 3, 4, 5, and 6, representing the number 3.

1. Extraction of Limestone

Figure 1. The effect of the number of trials on the number of correct responses. The number of correct responses (Y-axis) is plotted against the number of trials (X-axis). The data points show a positive correlation, indicating that the number of correct responses increases as the number of trials increases.

Limestone is mined from quarries using blasting and digging.

[illegible]

2. Crushing and Grinding

[illegible]

The limestone is crushed into smaller pieces and ground into a fine powder.

A large grid of 60 small dot patterns arranged in three rows and twenty columns. Each pattern consists of black dots on a white background, forming various shapes and symbols.

3. Mixing with Other Materials

Materials such as clay, sand, and iron ore are added to the limestone powder to improve cement quality.

[illegible]

4. Heating in Kiln

The mixture is heated in a rotary kiln at high temperatures to form clinker.

When the clinker is ground with gypsum, it produces cement powder, which is then packed for distribution.

5. Grinding and Packaging

Clinker is ground with gypsum to produce cement powder.

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The cement powder is then packed for distribution. The cement powder is then packed for distribution.

Uses of Cement in Uganda

Cement is used in various ways in Uganda.

- Building homes, schools, hospitals, and offices.

Cement is used in various ways in Uganda. Cement is used in various ways in Uganda.

- Road construction and infrastructure projects.

Cement is used in various ways in Uganda. Cement is used in various ways in Uganda.

- Manufacturing pre-cast blocks and tiles.

Cement is used in various ways in Uganda. Cement is used in various ways in Uganda.

Fun Facts about Cement Mining

Uganda produces over 3 million tons of cement annually.

- Uganda produces over 3 million tons of cement annually.

Cement mining creates jobs and supports local communities.

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Cement mining creates jobs and supports local communities.

PROJECT WORK



Relevance of Project Work to Learners

[illegible]

1. Connects Theory to Practice

[illegible]

Project work allows learners to apply what they learn in textbooks to real-life situations.

[illegible]

Instead of just memorizing facts, learners experience the concepts, making learning meaningful.

[illegible]

2. Develops Practical Competencies

Through projects, learners develop hands-on skills, problem-solving abilities, and creativity.

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For blind learners, tactile models, smell, and touch are used to experience chemical processes safely.

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3. Encourages Critical Thinking

Project work challenges learners to analyze, plan, and make decisions.

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For example, deciding how to filter water, produce biogas, or extract iron teaches reasoning and planning.

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4. Enhances Communication Skills

Learners present their projects orally or through tactile demonstrations.

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This improves verbal expression, storytelling, and peer teaching skills.

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5. Promotes Collaboration

Learners collaborate to complete projects and share their findings.

Many projects are done in teams.

Many projects are done in teams. Learners work together, assign roles, and share responsibilities, which builds teamwork and social skills.

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What You Need For Good Project Work

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1. Clear Problem Statement

What to do: Clearly define the problem your project addresses.

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Example: "This project demonstrates how water can be purified at home using a low-cost filtration system to improve health in our community."

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... ..
... ..

Why it earns marks: Shows understanding of context and relevance.

... ..
... ..
... ..

2. Objectives and Goals

... ..

What to do: State measurable objectives.

... ..
... ..

Example: “To remove sediments, reduce turbidity, and make water safe for drinking.”

... ..
... ..
... ..

Why it earns marks: Demonstrates clarity of purpose and planning.

... ..
... ..
... ..

3. Research and Background Information

What to do: Research the scientific theory, industrial process, or local context of the chemical.

Example: Explain how filtration works, or the chemistry of ammonia in fertilizers.

Why it earns marks: Shows understanding of underlying concepts.

What to do: List materials and explain procedures step by step.

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What to do: List materials and explain procedures step by step.

Why it earns marks: Shows understanding of underlying concepts.

4. Materials and Methods

What to do: List materials and explain procedures step by step.

Example: List materials and explain procedures step by step.

Why it earns marks: Shows understanding of underlying concepts.

Example: For water filtration: sand, gravel, charcoal, container; explain layering and filtering process.

Why it earns marks: Shows organization, planning, and safety awareness.

Example: Compare water before and after filtration using clarity, smell, or taste tests.

5. Observations and Data Collection

What to do: Record results carefully, even tactilely if needed.

Example: Compare water before and after filtration using clarity, smell, or taste tests.

Why it earns marks: Demonstrates practical skills and attention to detail.

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6. Analysis and Interpretation

What to do: Explain what the results mean.

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Example: “The filtered water is cleaner because the sediment and impurities were removed.”

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Why it earns marks: Shows critical thinking and ability to draw conclusions.

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7. Creativity and Innovation

What to do: Add unique solutions or improvements.

Example: Add a tactile indicator for blind users or use

locally available materials for filtration.

Why it earns marks: Teachers reward originality and problem-solving.

What to do: Add unique solutions or improvements.

Example: Add a tactile indicator for blind users or use

locally available materials for filtration.

8. Discussion on Relevance and Impact

What to do: Add unique solutions or improvements.

What to do: Explain how the project benefits society.

Figure 1: A diagram illustrating the structure of the proposed model. The top row shows the input sequence $x_1, x_2, \dots, x_n$ being processed by a sequence of blocks $f_1, f_2, \dots, f_n$ to produce the output sequence $y_1, y_2, \dots, y_n$. The bottom row shows the input sequence $x_1, x_2, \dots, x_n$ being processed by a sequence of blocks $g_1, g_2, \dots, g_n$ to produce the output sequence $z_1, z_2, \dots, z_n$. The blocks f_i and g_i are connected by a horizontal line, indicating a shared or related structure.

Example: “This filtration system can help families in rural Uganda access safe drinking water, preventing waterborne diseases.”

۱. در صورتی که در یک سال گذشته، شما به دلیل مشکلات مالی، نتوانسته باشید به موقع بدهی خود را بپردازید، این می‌تواند به عنوان یک نشانه هشدار برای اعتبار شما در نظر گرفته شود.

۲. اگرچه در حال حاضر به شما امکان می‌دهیم تا بدهی خود را بپردازید، اما اگر این روند ادامه یابد، ما مجبور خواهیم بود تا اقدامات قانونی را علیه شما اتخاذ کنیم.

۳. ما توصیه می‌کنیم تا به سرعت با ما تماس بگیرید و در مورد راه‌حل‌های ممکن برای تسویه بدهی خود گفتگو کنید.

۴. اگر شما به ما اطلاع دهید که قصد دارید بدهی خود را بپردازید، ما می‌توانیم تا حد امکان در فرآیند تسویه بدهی شما تسهیل‌گری کنیم.

۵. در صورتی که شما به ما اطلاع دهید که قصد دارید بدهی خود را بپردازید، ما می‌توانیم تا حد امکان در فرآیند تسویه بدهی شما تسهیل‌گری کنیم.

Why it earns marks: Shows connection to real-life and societal awareness.

[illegible]

9. Conclusion

What to do: Summarize the learning and outcomes.

Figure 1 displays a set of 16 dot patterns arranged in two rows of eight. The top row contains patterns for digits 0 through 7, and the bottom row contains patterns for digits 8 through 9. Each digit is represented by a specific configuration of black dots on a white background, forming a 10-class classification problem.

Example: “The project successfully demonstrates low-cost water purification and its importance in community

health.”

١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠
 ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠
 ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠
 ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠ ١٠٠٠

Why it earns marks: Clear summary shows understanding and completion.

[illegible]

10. Presentation and Report Quality

What to do: Organize the report neatly, use diagrams, tactile models for blind learners, and present orally.




































Why it earns marks: Teachers reward clarity, communication, and demonstration of concepts.

CHEMISTRY TABLES

Table 1: Colours of Common Metal Ions and Their Salts

Colours of Common Metal Ions and Their Salts

The following table lists the common metal ions and their corresponding salt colors. The colors are listed in the first column, and the corresponding metal ions are listed in the second column.

Zinc, Aluminum, Lead, Calcium, Ammonium and Magnesium ions all form white salts and colourless solutions.

The following table lists the common metal ions and their corresponding salt colors. The colors are listed in the first column, and the corresponding metal ions are listed in the second column.

ZALCAM is an acronym derived in order to master these metal ions.

The following table lists the common metal ions and their corresponding salt colors. The colors are listed in the first column, and the corresponding metal ions are listed in the second column.

Copper(II) ions form blue salts except copper(II) carbonate which is green

The following table lists the common metal ions and their corresponding salt colors. The colors are listed in the first column, and the corresponding metal ions are listed in the second column.

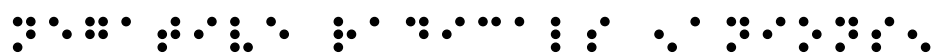
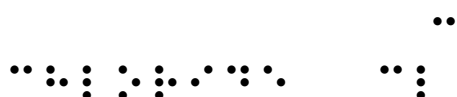
Iron(II) ions form green salts

The following table lists the common metal ions and their corresponding salt colors. The colors are listed in the first column, and the corresponding metal ions are listed in the second column.

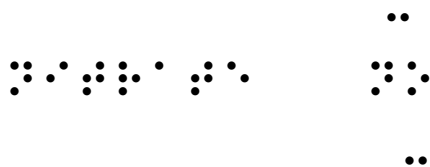
Iron(III) compounds are brown

The following table lists the common metal ions and their corresponding salt colors. The colors are listed in the first column, and the corresponding metal ions are listed in the second column.

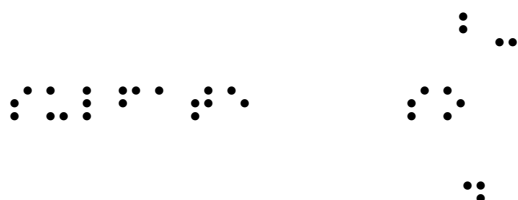
Negative Radicals (Anions)

Chloride Cl^- 

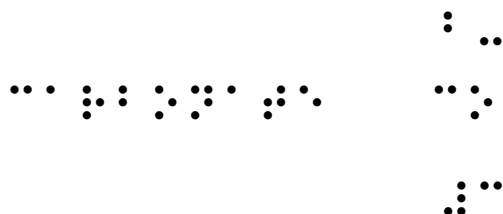
Nitrate NO_3^-



Sulfate SO_4^{2-}



Carbonate CO_3^{2-}



Hydroxide OH⁻



Oxide O²⁻



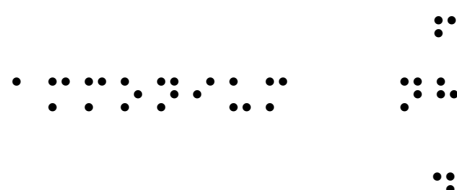
Positive Radicals (Cations)



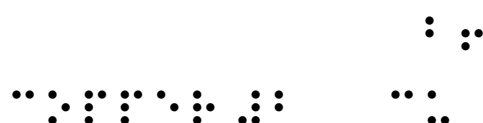
Hydrogen H⁺



Ammonium NH₄⁺



Copper(II) Cu²⁺



Iron(II) Fe²⁺



Iron(III) Fe^{3+}



Reactivity Series of Metals



Potassium



Sodium



Calcium



Magnesium



Aluminium



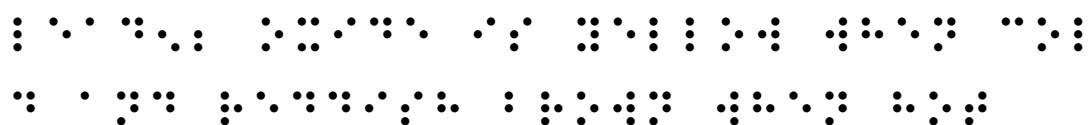
Zinc



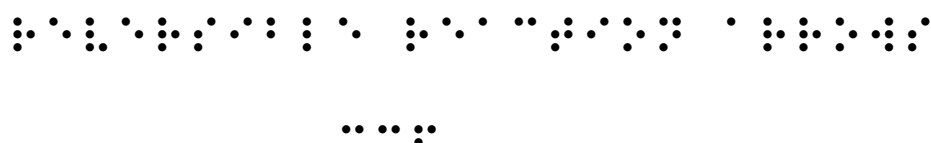
Iron



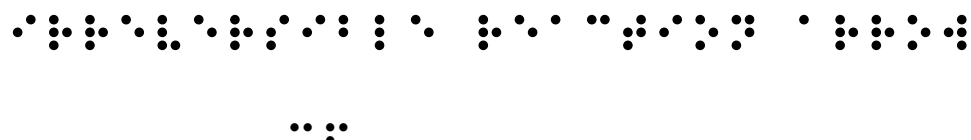
Lead(II) oxide is yellow when cold and reddish brown when hot



Reversible reaction arrows



Irreversible reaction arrow



NOTE:



The Nemeth symbol ($\cdot\ddot{\cdot}$) is ignored since the chemistry slate has those subscript and superscript

column cells allocated mainly for Nemeth code and states only.

[illegible]

The aqueous state (aq) is written as (q) in this system to reduce the confusion between "a" and "1" during the writing of chemical equations.

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840.